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QUIET RELIABLE GENERATORS FOR CORPS AND DIVISION HEADQUARTERS:
A HUMAN FACTORS AND SAFETY EVALUATION

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ARI RESEARCH NOTE 87-3620. Abstract (continued) from i

the test requirements and identified several commercial and military generators having the potential for satisfying the Army's needs and standards. Test results will be used to develop specifications for the acquisition of future generators.

Back to
pg i

QUIET RELIABLE GENERATORS FOR CORPS AND DIVISION HEADQUARTERS: A HUMAN FACTORS AND SAFETY EVALUATION

CONTENTS

	Page
INTRODUCTION.....	1
HUMAN FACTORS.....	3
Issue.....	3
Criterion.....	3
Methodology.....	3
Results and Analysis.....	3
SAFETY.....	149
Issue.....	149
Criterion.....	149
Methodology.....	149
Results and Analysis.....	150
RECOMMENDATIONS FOR PURCHASE DESCRIPTIONS.....	247
REFERENCES.....	251

LIST OF TABLES

Table 6-1. Number of Critical (C) and Noncritical (N) Human Factors Problems Identified for Each Type of Generator.....	4
7-1. Classification of Safety Problems.....	151-152
7-2. Number of Operators Checking Each Category in the Safety Questionnaire (Manufacturer A, 1.5 kW, 28 vDC, Skid-Mounted Generator).....	153
7-3. Number of Operators Checking Each Category in the Safety Questionnaire (Manufacturer A, 1.5 kW, 28 vDC, Boxed Generator).....	155
7-4. Number of Operators Checking Each Category in the Safety Questionnaire (Manufacturer B, 3 kW, 28 vDC Generator).....	157
7-5. Number of Operators Checking Each Category in the Safety Questionnaire (Manufacturer C, 5 kW, 60 Hz Generator).....	167

CONTENTS (Continued)

	Page
Table 7-6. Number of Operators Checking Each Category in the Safety Questionnaire (Manufacturer D, 5 kW, 60 Hz Generator).....	171
7-7. Number of Operators Checking Each Category in the Safety Questionnaire (Manufacturer E, 5 kW, 60 Hz Generator).....	174
7-8. Number of Operators Checking Each Category in the Safety Questionnaire (Manufacturer A, 10 kW, 60 Hz Generator, Modified).....	177
7-9. Number of Operators Checking Each Category in the Safety Questionnaire (Manufacturer D, 10 kW, 60 Hz Generator).....	181
7-10. Number of Operators Checking Each Category in the Safety Questionnaire (Manufacturer E, 10 kW, 60 Hz Generator).....	185
7-11. Number of Operators Checking Each Category in the Safety questionnaire (Manufacturer A, 15 kW, 60 Hz Generator, Modified).....	189
7-12. Number of Operators Checking Each Category in the Safety Questionnaire (Manufacturer B, 15 kW, 60 Hz Generator).....	193
7-13. Number of Operators Checking Each Category in the Safety Questionnaire (Manufacturer F, 15 kW, 60 Hz Generator).....	198
7-14. Number of Operators Checking Each Category in the Safety Questionnaire (Manufacturer A, 30 kW, 60 Hz Generator, Modified with Baffling on Doors and Exhaust System).....	202
7-15. Number of Operators Checking Each Category in the Safety Questionnaire (Manufacturer AW, 30 kW, 60 Hz Generator).....	206
7-16. Number of Operators Checking Each Category in the Safety Questionnaire (Manufacturer AQ, 30 kW, 60 Hz Generator).....	210
7-17. Number of Operators Checking Each Category in the Safety Questionnaire (Manufacturer G, 30 kW, 60 Hz Generator).....	213

CONTENTS (Continued)

	Page
Table 7-18. Number of Operators Checking Each Category in the Safety Questionnaire (Manufacturer H, 30 kW, 60 Hz Generator).....	217
7-19. Number of Operators Checking Each Category in the Safety Questionnaire (Manufacturer I, 30 kW, 60 Hz Generator).....	224
7-20. Number of Operators Checking Each Category in the Safety Questionnaire (Manufacturer A, 60 kW, 400 Hz Generator).....	228
7-21. Number of Operators Checking Each Category in the Safety Questionnaire (Manufacturer H, 60 kW, 60 Hz Generator).....	232
7-22. Number of Operators Checking Each Category in the Safety Questionnaire (Manufacturer J, 60 kW, 60 Hz Generator).....	237
7-23. Number of Operators Checking Each Category in the Safety Questionnaire (Manufacturer I, 100 kW, 60 Hz Generator).....	242

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QUIET RELIABLE GENERATORS FOR CORPS AND DIVISION HEADQUARTERS: A HUMAN FACTORS AND SAFETY EVALUATION

EXECUTIVE SUMMARY

Requirement:

In July 1984, the Army Vice Chief of Staff directed that sound-attenuated commercial generators and product-improved military standard generators be provided to one corps and one division headquarters for operational testing by March 1985. The purpose of the test was to provide user input to help understand the capability of commercial and military standard generators to meet the mobile electric power needs and noise limit standards of Army units in the field. Headquarters, TCATA at Fort Hood, Texas, was chosen as the test agency and the ARI Field Unit-Fort Hood was tasked to address the human factors and safety issues of the test. The following report is in response to that tasking.

Procedures:

Human factors psychologists observed generator operations on-site and completed safety check lists. Physical dimensions and sound levels were measured. In addition, questionnaires and interviews were administered to operators and drivers of test generators during the latter stages of field exercises at Ft. Huachuca, Arizona, and Ft. Hood, Texas. Ratings and comments were obtained about the adequacy of each generator with respect to human factors and safety engineering. Specific information was obtained about the operational environment around the generator, indicator lights, gauges, controls, power connections, equipment location, workspace, storage space, operational procedures, maintenance procedures, operator's manual, tools, trailer, and safety hazards. This information was analyzed by human factors psychologists at ARI. Human factors problems were classified as either critical or non-critical and were associated with their respective violations of MIL-STD-1472C. Safety problems were classified according to the 4 hazard severity categories and the 6 hazard probability levels described in MIL-STD-882A. Recommendations were made concerning equipment redesign and alternate operating procedures.

Results and Recommendations:

Human Factors. Each of the generators evaluated in this report has a number of human factors problems associated with it. A review of these problems led to the following list of design features which should be present on all mobile generator systems used by the Army.

1. A fuel gauge, water/coolant gauge, and oil gauge (or oil dipstick) should be located externally to the acoustical housing surrounding the

generator. More specifically, all gauges should be located on the operator's control panel. The fill points for fuel, water/coolant, and oil should also be located externally to the acoustical housing. The fuel fill should be located at trailer level at a safe distance from the batteries; the water/coolant fill should be located on top of the acoustical housing; and the oil fill should be located on the top or sides of the acoustical housing. Each system should be designed so that the generator can be serviced while it is running. Placing the fill points external to the sound-reducing equipment would allow servicing of the generator without jeopardizing the concealment tactics of a military unit, and would make servicing the generator easier.

2. The power connections compartment should be designed for accessibility, potential operational requirements, and safety. The lug terminals should be large enough and spaced far enough apart so that four or five large cables can be readily connected to the generator. The compartment should have a safety cover that can be secured in the "opened" position while cables are being connected and can be lowered to provide a safe, waterproof environment after the cables are connected. The entire power connections compartment should be located away from highly-trafficked areas, such as the immediate space around the operator's control panel. An operator cannot work efficiently or safely around a generator if he has to constantly climb over power cables.

3. In order to avoid equipment damage and personnel injury, the label for a designated terminal on an Army-procured commercial generator should be consistent with the label for the corresponding terminal on a military standard generator.

4. Access doors in the acoustical housing should be self-supporting so they can be opened quickly and easily. They should be hinged on one side and latched on the other (with tongue-and-slot catches). Multiple-turn latches should not be used since they interfere with normal and emergency operations of a generator. The doors should have positive locks or braces to secure them when they are in the "opened" position. (The "opened" position for an access door should be reached by a horizontal movement of the door, rather than a vertical movement.)

5. All indicator lights, gauges, and controls for the generator should be located on (or near) the operator's control panel. The entire control panel should be located externally to the acoustical housing and located in a readily accessible area around the generator. In addition, the control panel should be placed at eye-level for an average-height soldier standing on the ground. Placing the control panel at a proper height would make the generator easier to use during normal and emergency conditions.

6. Natural and artificial illumination around the operator's control panel should provide sufficient light for a variety of tactical situations. External, white lights should be used for panel lights and low luminance, integral red lights should be used for all gauges. The brightness of all lights should be adjustable and all lights should be extinguishable with on-off switches. This light configuration would allow maximum flexibility for operating during daytime, nighttime, and blackout conditions.

7. The batteries should be mounted side by side and located in a separate compartment having its own access door. When the door is opened, the batteries should slide in and out easily. The operator should be able to access each battery individually, without difficulty.

8. A generator/trailer should be sufficiently rugged to be towed successfully across rough terrain and still complete its mission. The size and weight of the generator should be compatible with the size and weight of the trailer. The center of gravity of the generator/trailer should be properly located so the generator/trailer is easy to tow, easy to set in place manually, and stable when at rest. The brakes should be reliable; in particular, they should not lock up during forward or backward movement. The tire configuration, tire size, and fender skirt design should facilitate transporting the generator and changing the tires. The chassis of the trailer should be high enough off the ground so the trailer does not drag when traveling over rough or hilly terrain.

9. The hook-up mechanism on the trailer should be designed so that one or two soldiers can easily and quickly hook the generator/trailer onto a tow vehicle, or remove the generator/trailer from the tow vehicle when it reaches its destination. The landing gear should be sturdy and easily cranked up and down. The trailer hook should protrude out enough so that the tow vehicle can make turns without damaging the tow bar of the trailer. The safety chains should be long enough and strong enough to ensure safe travel. The trailer should have a hand brake (rather than air brakes) to use when the generator/trailer is stationary.

10. The amount of workspace around the generator should be sufficient for the operator to perform his duties in a safe and timely manner. The design of the workspace should also facilitate the accomplishment of maintenance tasks. More specifically, walkways on the fender skirts should be at least 27 inches wide and be coated with skid-resistant material. Steps should be added to the sides of the trailer to assist operators when they mount the walkways. Handholds and footholds should be mounted on the sides of the acoustical housing of any generator which requires operators to climb on top of the housing to perform checks and services.

11. The amount of storage space on the generator/trailer should be sufficient for storing special tools, spare parts, fuel cans, fuel filters, oil cans, oil filters, grounding rods, and an operator's manual. The storage space should be lockable, so that pilferage can be controlled.

Safety. Each of the generators evaluated in this report has a number of safety problems associated with it. A review of these problems led to the following list of safety features which should be present on all mobile generator systems used by the Army.

1. Generators should have a green indicator light on the operator's panel to indicate when power is on. In addition, the main power switch should be located on the operator's panel and should be labeled "Main Power On-Off." The absence of these features may cause a lack of awareness as to whether or not electrical power is being applied to the power distribution system. If power is being applied with no external indications of that fact, a soldier may

inadvertently come in contact with (and suffer injury from) cables or terminals under load.

2. Terminal lug areas should have protective covers which prevent soldiers from inadvertently contacting terminals under load. In addition, the area should be labeled to conform with MIL-STD (military standard) 454, ANSI (American National Standards Institute) Z35.1-1972, and TECOM TOP (Test Operating Procedure) 6-2-507. Voltages in the range of 70 to 500 should be labeled with "CAUTION HIGH VOLTAGE" in yellow gothic capitals on a black background and with "XXX VOLTS" in black numbers/letters on a yellow background.

3. Ground rods and straps should be provided as part of each generator system.

4. A clearly identified, emergency shut-off control should be provided on generator systems which are normally shut down in several stages. The control should allow an operator or bystander to immediately and easily shut down the generator in case of an emergency.

5. Fan blades, belts, and pulleys should have protective guards around them to prevent a soldier from inadvertently getting a limb or clothing caught in moving parts.

6. The fuel fill should be located externally to the acoustical housing. Refueling typically involves some spillage of fuel, even when care is taken to avoid such an occurrence. When the fuel fill is located inside the acoustical housing, spilled fuel tends to accumulate and pose a fire hazard.

7. Exhaust gases should be directed upwards or downwards so that they are not vented directly at soldiers who are working on the generator or walking by it. In addition, the exhaust vent should be designed so that a tubular extension can be added to it. The extension could remove exhaust gases and fumes a safe distance from the generator if it were operating in an enclosed area.

8. Doors for the acoustical housing should be designed to allow rapid access to the generator and engine in case of emergencies such as fires. The access doors should be self-supporting, hinged on one side, and latched on the other (with tongue-and-slot catches). In addition, the hinged doors should have a positive locking mechanism which secures them when they are opened and prevents their being caught by the wind and slammed against an operator or bystander.

9. Corners and edges on the trailer, the access doors, and other parts of the generator/trailer should be rounded to reduce the number and severity of injuries to soldiers who accidentally fall against them.

10. The 1.5 KW generators should be labeled to indicate their weight. They are relatively heavy (over 100 pounds) but are small enough that they will be manually carried by soldiers from vehicles to emplacement locations.

11. To conform with MIL-STD-1474B(MI), generators should be marked with a "CAUTION, HEARING PROTECTION REQUIRED" stencil if their steady state noise level reaches 85 dB(A). The "CAUTION" should be in yellow gothic capitals on a black background, and the "HEARING PROTECTION REQUIRED" should be in black letters on a yellow background.

12. Walking spaces on trailer floors and fenders should have non-slip surfaces to prevent soldiers from slipping when the walkways are wet from rain, spilled oil, or spilled fuel.

13. Trailers should have safety chains which can be attached to the tow vehicle to prevent a trailer from breaking loose from the vehicle if the tow bar breaks.

14. Permanently fixed ladders or footholds/handholds should be mounted on the sides of the acoustical housing of those generators which require operators to climb on top of the housing to perform checks and services.

Utilization:

Information from this evaluation will be used by the United States Army Engineering School (USAES), the Army Material Command (AMC), Forces Command (FORSCOM), the Project Manager-Mobile Electric Power (PM-MEP), and other appropriate Army agencies to develop specifications for the acquisition of future generators for the Army.

QUIET RELIABLE GENERATORS FOR CORPS AND DIVISION HEADQUARTERS:
A HUMAN FACTORS AND SAFETY EVALUATION

INTRODUCTION

In July 1984, the Army Vice Chief of Staff directed that sound-attenuated commercial generators and product-improved military standard generators be provided to one corps and one division headquarters for operational testing by March 1985. The purpose of the test was to provide user input to help understand the capability of commercial and military standard generators to meet the mobile electric power needs and noise limit standards of Army units in the field. The US Army Engineer School (USAES), in conjunction with the US Army Materiel Command (AMC), US Army Forces Command (FORSCOM), and the Project Manager-Mobile Electric Power (PM-MEP), defined the operational test requirements and identified several commercial and military generators having the potential for satisfying these needs and standards. Fort Hood, Texas, was chosen as the test site and the TRADOC Combined Arms Test Activity (TCATA) at Fort Hood was chosen as the test agency. TCATA, in turn, tasked the ARI Field Unit-Fort Hood to address the human factors and safety issues of the test.

The generators began arriving at Fort Hood in mid-January 1985. A representative of the PM-MEP arrived with a team of personnel in early March 1985. The PM-MEP team's initial responsibility was to assist Fort Hood elements in the receipt, storage, checkout, and issue of the generators and to coordinate the contractor-conducted training of key personnel in each unit which received generators. After all generators of a particular make and model had arrived and been checked and serviced, they were issued to military units for testing purposes. The operational test was conducted during field exercises at Fort Huachuca, Arizona, and at Fort Hood, Texas, from 1 April through 31 May 1985.

Human factors psychologists with the ARI Field Unit-Fort Hood observed generator operations on-site and completed safety check lists. Physical dimensions and sound levels were measured. The degree of conformance to MIL-STD 1472C and 882A was noted. The psychologists administered questionnaires and interviews to operators and drivers of test generators during the latter stages of field exercises at Ft. Huachuca, Arizona, and Ft. Hood, Texas. Ratings and comments were obtained about the adequacy of each generator with respect to human factors and safety engineering. Specific information was obtained about the operational environment around the generator, indicator lights, gauges, controls, power connections, equipment location, workspace, storage space, operational procedures, maintenance procedures, operator's manual, tools, trailer, and safety hazards. This information was analyzed for each of the 25 different types of test generators. Human factors problems were classified as either critical or non-critical and were associated with their respective violations of MIL-STD-1472C. Safety problems were classified according to the 4 hazard severity categories and the 6 hazard probability levels described in MIL-STD-882A. Recommendations were made concerning equipment redesign and alternate operating procedures.

The ARI research was approved and formally published as Chapter 6: "Human Factors Results" and Chapter 7: "Safety Results" of TCATA TEST REPORT OTN 1209, Quiet Reliable Generators For Corps and Division Headquarters, August 1985. In the interests of cost effectiveness (resulting from not having to retype the entire report) these chapters are reproduced here in the same format and with the same paragraph numbering as found in the above-referenced TCATA report.

CHAPTER 6

6. Human Factors

6.1 Issue. Is the system adequately designed with regard to sound human factors engineering principles?

6.1.1 Criterion. The system design will comply with the human factors requirements of MIL-STD-1472C.

6.1.2 Methodology.

6.1.2.1 Near the end of each field exercise, human factors psychologists administered questionnaires and conducted structured interviews with the operators of each type of generator system. Ratings and comments were obtained about the adequacy of each system with respect to human factors engineering. The questionnaire required each operator to rate the adequacy of various aspects of a generator system on a five-point rating scale. One scale used the following set of verbal descriptors: Very Adequate, Adequate, Neither Adequate nor Inadequate, Inadequate, and Very Inadequate. Another scale used a different set of verbal descriptors: Very Easy, Easy, Neither Easy nor Difficult, Difficult, and Very Difficult. Choices of "Did Not Perform" and "Not Applicable" were also provided. The ratings for each generator system were tabulated for each human factors question in each rating category. Operators' comments from the questionnaires and interviews were categorized and summarized by human factors psychologists. [A copy of the Human Factors Questionnaire is available upon request from the Army Research Institute Field Unit - Fort Hood, Texas.]

6.1.2.2 Observations and measurements by human factors psychologists, and ratings and comments by operators were compared to the requirements of MIL-STD-1472C to determine if human engineering military standards were violated. In addition, problems revealed by the ratings and comments were classified as critical or non-critical. Critical problems were those which would probably cause mission failure, equipment failure, or safety incidents. Non-critical problems were those which would probably not cause mission failure, equipment failure, or safety incidents.

6.1.2.3 Data summaries from the human factors questionnaire and interviews are too voluminous to be presented as part of this report. In order to condense and summarize the questionnaire and interview results, the human factors psychologists used their professional judgement and the experiences gained from observing the operation of the generators in the field. The results are presented in the following paragraphs. [Data summaries and copies of the actual data may be obtained upon request from the Army Research Institute through Commander, TCATA, Battlefield Automation Test Directorate, ATTN: ATSTD, Ft. Hood, TX 76544-5065.]

6.1.3 Results and Analysis. The numbers of critical and non-critical human factors problems for each generator are summarized in Table 6-1.

TABLE 6-1. NUMBER OF CRITICAL (C) AND NONCRITICAL (N) HUMAN FACTORS PROBLEMS IDENTIFIED FOR EACH TYPE OF GENERATOR.

a/ The operator of this generator could not be identified.

b/ The operator gave no adverse rating and made no comments.

c/ This generator was not used in the field during the test.

6.1.3.1 Manufacturer A, 1.5 kW, 28 vDC Generator, Modified, Skid-Mounted

6.1.3.1.1 Ratings Made By One Operator

- a. Environment. The operator gave "Acceptable" ratings to noise, temperature, and light levels, but rated vibration level as "Somewhat too high".
- b. Indicator Lights. The operator gave "Adequate", "Very Adequate" or "Not Applicable" ratings to the indicators.
- c. Gauges. The operator gave "Adequate" and "Not Applicable" ratings to the gauges.
- d. Controls. The operator indicated that the resistance of the pull starter was too hard.
- e. Power Connections. The operator gave "Adequate" and "Not Applicable" ratings to power connections.
- f. Equipment Location. The operator generally gave "Adequate" and "Not Applicable" ratings to the location of various components of the generator.
- g. Workspace and Storage Space. The operator gave "Adequate" and "Not Applicable" ratings to workspace and storage space.
- h. Operational Procedures. The operator generally gave "Easy" ratings to operational procedures, and indicated that he did not operate the generator while wearing MOPP gear.
- i. Maintenance Procedures. The operator indicated that it was "Neither Easy Nor Difficult" to perform PMCS on the generator, and it was "Easy" to troubleshoot problems with the generator. He did not perform any maintenance while in MOPP gear.
- j. Operator's Manual. The operator indicated that he used the manual from one to five times, and generally gave it "Adequate" and "Easy" ratings.
- k. Tools. The operator indicated that tools available for troubleshooting were "Adequate".

6.1.3.1.2 Comments Made By One Operator

- a. Environment. The operator commented: The generator vibrated because we had to mount it in a trailer ourselves, and we were not sure what we were doing. That is why it vibrated. Also, it was hard to tell the run switches from each other at night because it was hard to see the stencil on the paint.
- b. Indicator Lights. No comments.
- c. Gauges. No comments.

d. Control. The operator commented: It was hard to operate the pull starter because the rope did not automatically retract each time. You had to rewind the rope each time you tried to pull start the generator. I would like a change to an electric starter.

e. Power Connections. No comments.

f. Equipment Location. No comments.

g. Workspace and Storage Space. The operator commented: There is adequate space for storing gas cans on the same trailer in which we put the generators. We put ground rods in the back of the trucks.

h. Operational Procedures. The operator commented: The generators were easy to operate due to their size.

i. Maintenance Procedures. The operator commented: There were only a few things, like oil and fuel, to maintain. So it was convenient to maintain and operate them.

j. Operator's Manual. The operator commented: The manual we had was for the old 1.5 KW, and since the generators are almost the same we had no problems using it.

k. Tools. No comments.

6.1.3.1.3 Analysis

Analysis of the preceding results led to the identification of human factors problems and the classification of these problems into the following critical and non-critical categories:

a. Critical Problems. None.

b. Non-Critical Problems

Problem: It was somewhat difficult to see the labels on the switches at night.

Violation of MIL-STD-1472C: Section 5.5.4.3

Recommendation: The labels should be printed so that they can be read easily and accurately at night with the amount of illumination available from a red lens flashlight.

6.1.3.2 Manufacturer A, 1.5 kW, 28 vDC Generator, Modified, Boxed

6.1.3.2.1 Ratings Made By Two Operators

a. Environment. Operators generally gave "Acceptable" ratings to noise, vibration and light levels near the generator, although one of the operators indicated that temperature levels near the generator during normal operation were "Somewhat too high."

b. Indicator Lights. The operators generally gave "Adequate" ratings to the indicator lights.

c. Gauges. One operator gave "Adequate" and "Not Applicable" ratings to questions about gauges. The other operator gave no ratings to gauges.

d. Controls. The operators generally gave "Adequate" and "Not Applicable" ratings to controls.

e. Power Connections. One operator gave no ratings on this section. The other operator gave an "Adequate" rating to ease of connecting power cables, and gave an "Inadequate" rating to a characteristic he added to the questionnaire, called "gas line".

f. Equipment Location. The operators generally gave "Adequate" or "Not Applicable" ratings to the location of various components of the generator. One operator gave an "Inadequate" rating to the location of the oil fill.

g. Workspace and Storage Space. The operators generally gave "Adequate" and "Not Applicable" ratings to workspace and storage space. One operator gave no rating to storage space.

h. Operational Procedures. The operators generally gave "Easy" ratings to operational procedures. One operator indicated that he did not operate the generator in MOPP gear, and the other operator gave "Easy" ratings to setting up, starting, and stopping the generator while wearing MOPP gear.

i. Maintenance Procedures. One operator indicated that it was "Neither Easy Nor Difficult" to perform PMCS on the generator, that it was "Easy" to troubleshoot problems with the generator, and that he did not perform any maintenance in MOPP gear. The other operator gave no ratings to maintenance procedures.

j. Operator's Manual. One operator indicated that there was no manual with the generator. The other operator indicated that he had used the manual from one to five times and he generally gave "Adequate" and "Easy" ratings to it.

k. Tools. One operator indicated that the tools available for troubleshooting the generator were "Adequate". The other operator gave no rating.

6.1.3.2.2 Comments Made By One Operator

a. Environment. One operator commented: The combination of the engine producing heat and being set out in the sun resulted in the outside of the case getting too hot. Also, you need light to be able to get the dipstick back in place; it is down in there.

b. Indicator Lights. No comments.

c. Gauges. No comments.

d. Control. One operator commented: The pull start was alright.

- e. Power Connections. No comments.
- f. Equipment Location. One operator commented: The oil fill is too inaccessible.
- g. Workspace and Storage Space. No comments.
- h. Operational Procedures. One operator commented: The generator was easy to operate because of its size.
- i. Maintenance Procedures. One operator commented: There were only a few things, like oil and fuel, to maintain. So it was convenient to maintain and operate them. However, the hoses we use to run fuel from our five-gallon gas cans do not fit on the nozzle of the generator.
- j. Operator's Manual. One operator commented: The manual we had was for the old 1.5 KW, and since the generators are almost the same we had no problems using it.
- k. Tools. No comments.

6.1.3.2.3 Analysis

Analysis of the preceding results led to the identification of human factors problems and the classification of these problems into the following critical and non-critical categories.

a. Critical Problems

Problem: The fuel line connection on the generator is not the same size as that on the rubber fuel hose from the five-gallon fuel can. Consequently, the rubber fuel hose that is part of the siphon mechanism will not fit onto the generator fuel fill.

Recommendation: Provide an adaptor that will allow the fuel hose from the five-gallon fuel can to fit onto the generator fuel line connection.

b. Non-Critical Problems

Problem: The location of the oil fill makes it difficult to add oil unless the operator has a funnel.

Violation of MIL-STD-1472C: Section 5.9.5.1

Recommendation: Provide a funnel with the generator to facilitate adding oil.

6.1.3.3 Manufacturer B, 3 kW, 28 vDC Generator

6.1.3.3.1 Ratings Made By Ten Operators

a. Environment. Eight operators gave "Acceptable" ratings for the noise level of the generator for tactical operations. Ten operators gave "Acceptable" ratings for the noise level during operator maintenance. Nine operators gave "Acceptable" ratings for the vibration level near the generator during normal operations. Seven operators gave "Acceptable" ratings for the temperature level near the generator during normal operations. Ten operators gave "About right" ratings for the daytime light levels near the generator during normal operations. Five operators gave "Not Applicable" ratings for nighttime light levels at the operator's panel--because the operator's panel has no lights. Nine operators gave "About right" ratings for the nighttime light levels at the operator's panel during blackout conditions.

b. Indicator Lights. In general, the operators were satisfied with the indicator lights. Four, five, or six operators gave "Adequate" ratings for every item in this section. One operator rated the Load-on Light as "Very Adequate"--and stated that this light was the only indicator on the generator.

c. Gauges. In general, the operators were satisfied with the gauges. Seven, eight, nine, or ten operators gave "Adequate" and "Very Adequate" ratings for every item in this section. The only "Inadequate" rating was given for the brightness of gauges at night.

d. Controls. In general, the operators were satisfied with the controls. Seven, eight, or nine operators gave "Adequate" and "Very Adequate" ratings for every item in this section. One operator gave "Inadequate" ratings for "Type of control" and "Accessibility" of controls. Two operators gave "Inadequate" ratings to "Spacing between controls" and "Resistance".

e. Power Connections. In general, the operators were satisfied with the power connections. Eight or nine operators gave "Adequate" and "Very Adequate" ratings for every item in this section. One operator gave an "Inadequate" rating for "Ease of connecting cables."

f. Equipment Location. In general, the operators were satisfied with the location of equipment. Eight or nine operators gave "Adequate" and "Very Adequate" ratings for the location of the following items: Operator's control panel, Indicator lights, Gauges, Start-Stop switch, Emergency Stop-Run switch, Governor control, Choke control, Fuel fill, and Oil fill. A preponderance of "Not Applicable" ratings was given to the following items: Batteries, Fuel selector switch, Storage compartments, Configuration on trailer, and Water/Coolant fill. Two operators gave "Inadequate" and "Very Inadequate" ratings for the configuration on trailer (or track vehicle in this case). One operator gave an "Inadequate" rating for the location of the fuel fill.

g. Workspace and Storage Space. The items in this section of the questionnaire were not applicable. There was no acoustical enclosure around the generator, the generator did not have to be physically mounted by the operator, and there was no storage space on the generator.

h. Operational Procedures. In general, the operators were satisfied with the operational procedures that were applicable. Eight or nine operators gave "Adequate" and "Very Adequate" ratings for the following items: Locate generator in place, Set up generator and prepare for starting, Stop generator normally, Prepare generator for transit, Transport generator, and Operate generator while performing other duties. Three operators gave "Inadequate" and "Very Inadequate" ratings for starting up the generator manually (with pull rope).

i. Maintenance Procedures. In general, the operators were satisfied with the maintenance procedures that were applicable. Six, seven, or eight operators gave "Easy" and "Very Easy" ratings for the following items: Perform overall check of generator system, Check load wire attachment, Check instruments for normal operation, Check engine oil, Check for fuel leaks, and Refuel generator. The operators gave a preponderance of "Did Not Perform" and "Not Applicable" ratings to the following items: Replace lamps and fuses, Check batteries, Service batteries, Change engine oil, Check oil filter, Replace oil filter, Check radiator, Service radiator, Check fuel filter, and Replace fuel filter. No operator gave a "Difficult" or "Very Difficult" rating for troubleshooting a failure of generator to start.

j. Operator's Manual. Five operators stated that an operator's manual was present with the generator and five stated a manual was not present. In general, the five operators who had access to a manual rated the manual organization as "Adequate", the description of equipment as "Adequate", the explanation of procedures as "Adequate", and the understandability of texts, tables, and diagrams as "Easy." These five operators rated the manual overall as "Accurate", "Comprehensive", and "Effective."

k. Tools. Five of seven operators rated the normally-issued tools as "Adequate" for performing PMCS. The troubleshooting item received a variety of responses--this was probably due to confusion as to how much troubleshooting an operator is authorized to do.

l. Trailer. Most of the generators were mounted on top of command tracks for this exercise. However, two generators were mounted on a small trailer and operated by two operators. One operator gave "Adequate" and "Very Adequate" ratings to all items except "Location of power box on trailer" and "Design features for mounting trailer safely." These two items received "Inadequate" ratings. The other operator gave "Neither Inadequate Nor Adequate" and "Adequate" ratings to all items except "Overall Size and Weight of Trailer", "Length of Trailer", "Width of Trailer", "Height of Chassis Above Ground", and "Suitability of Power Box For General Use." The latter five items were given "Inadequate" ratings.

6.1.3.3.2 Comments Made By Ten Operators

a. Environment

1. Two operators commented: For nighttime operations, the gauges on the operator's panel should be lit up internally. An external light, including a red lens flashlight, is too bright for tactical operations.

2. One operator commented: The temperature level near the generator during normal operation is somewhat too high. When the generator is running, a lot of heat goes into the command track.

3. One operator commented: The bright green light (i.e., the Load On-Off light) should be changed to a red light or have a dimmer mechanism on it.

4. One operator commented: The generator should have red lights on the control panel and near the crank so you can see what you're doing at night. This would help prevent injuries.

b. Indicator Lights

1. One operator commented: The Load-On light is very adequate. This green light is the only light on the generator and it lights up the whole panel. It's such a small generator, you don't need any other lights on it.

2. One operator commented: The brightness of the main indicator light is inadequate for night operations. The light is too bright--it should be dimmed.

3. One operator commented: The one indicator light is not bright enough to allow the operator to see the gauges at night. So, the gauges should be internally lit.

4. One operator commented: The amount of information given by the indicator lights is inadequate. We only have one light and it just tells you when the load is on.

c. Gauges

1. One operator commented: The location of the gauges is very adequate. They're right there on top, where you have to pull to start it. They're easy to see and very convenient for someone who hasn't worked on the generator before. He can just start it right up.

2. One operator commented: The gauges aren't lit up at night, so we need a flashlight to read them. We need internally-lit, red lens gauges so they can be seen and read at night during blackout conditions (as well as normal conditions).

3. One operator commented: The gauges for output volts and output current could use small lights inside to show the numbers more clearly at night. If this can't be done, a flashlight works just as well.

4. Two operators commented: The gauges should be lighted.

d. Controls

1. Two operators commented: I like the lawn mower or pull start on it because you don't have to rely on batteries. It started easily, except when we let it run out of fuel, and then it took a few cranks to get the fuel back through the system.

2. One operator commented: We only had to work with two controls—i.e., the start switch and the "Load On" switch. They were both easy to work with.

3. One operator commented: Pull starting is a little hard, but after the generator gets warm—it starts easily.

4. One operator commented: The cable for starting is blocked slightly by one of the bars on the mount. You can't pull straight out because of this bar. Having to pull at an angle makes the generator difficult to start.

e. Power Connections

1. One operator commented: Although connecting the cable isn't too difficult, it could be improved—particularly for night operations.

2. One operator commented: It is somewhat difficult at times to connect the cables.

3. One operator commented: We need a 110 Volt outlet on the generator so we can run other things inside the track. This would provide an additional source of power, since our tracks have no outlets themselves.

f. Equipment Location

1. Two operators commented: The generators placed on trailers (rather than those placed on command tracks) were too close together, creating a dangerous situation for the operators. There was no space to work around the generators.

2. One operator commented: Having to use that jerry can is kind of silly. Why don't you just put on a regular gas tank with a fuel gauge?

3. Two operators commented: The muffler is in a prominent position on top of the generator. It is painted bright silver and stands out when it's situated in the field. You can see it from far away. It should be painted a different color, such as green or brown, so it would blend in with the other camouflage.

4. One operator commented: Everything is located in a good place.

g. Workspace and Storage Space. Two operators commented: There was not enough room to work on the trailer. It was hard to get around the generators at night. They were too close together and there were not a lot of secure places to walk on the trailer.

h. Operational Procedures

1. One operator commented: The generator was hard to pull start when it was cold (but not when it was hot). However, the generator was easier to start than the 4.2 KW generator we normally use.

2. One operator commented: The hard part of manually starting the generator was having to pull start while the generator was on top of the track.

3. One operator commented: It's fairly easy to run and maintain the generator without MOPP gear. The generator is one of the easiest things I've ever worked with.

i. Maintenance Procedures

1. One operator commented: It's easy to pull oil checks and to refuel.

2. One operator commented: Compared with the 4.2 KW mil std generator, this generator is a lot quieter, a lot smaller, easier to access and hook-up, easier to run, runs longer on the same amount of fuel, and doesn't burn oil as fast as the 4.2 does.

j. Operator's Manual

1. Two operators commented: The military manuals have a PMCS chart, but this manual doesn't. Also, the manual said nothing about grounding. So, we figured it was self-grounding and didn't ground it ourselves.

2. One operator commented: There was too much bull about electrical diagrams in the operator's manual. Operators don't need to know this, nor can most average persons read electrical diagrams.

3. One operator commented: The manual was useful in the field.

k. Tools. No comments were made about the adequacy of normally-issued tools.

l. Trailer

1. One operator commented: You should make more room around and between the pair of generators mounted on the trailer. They are presently in an unsafe configuration.

2. One operator commented: The rope start is insufficient. You should have a switch start for speedier and quicker action.

3. One operator commented: It is very dangerous climbing onto the trailer at night, because there are not enough secure places to walk.

6.1.3.3.3 Ratings Made By Drivers

Most of the generators were carried to the field on command track vehicles. Driver ratings are not appropriate for this configuration, so none were solicited. A few generators were mounted in pairs on a trailer, but no driver ratings were collected for this generator/trailer configuration.

6.1.3.3.4 Comments Made By Drivers

No comments were received.

6.1.3.3.5 Analysis

Analysis of the preceding results led to the identification of human factors problems and the classification of these problems into the following critical and non-critical categories:

a. Critical Problems

Problem: The generators that were placed on trailers were mounted in such a way that they were very close together and there was little space available for working around them. This was a problem not only with respect to workspace but also with respect to safety.

Violations of MIL-STD-1472C: Sections 4.4(d), 4.4(m), and 5.14.2.3

Recommendation: For trailer-mounted applications, a trailer should be provided which allows sufficient room (at least 27 inches according to MIL-STD-1472C, Section 5.14.2.3) for a person to safely pass between the two mounted generators.

b. Non-critical Problems

1. **Problem:** The indicator light on the control panel was too bright for tactical light discipline at night. At the same time, there was not adequate lighting to be able to see the gauges on the control panel at night.

Violations of MIL-STD-1472C: Sections 5.1.1.5 and 5.2.1.2.1

Recommendation: Use external white lights on the operator's panel and low luminance, integral red lights for all gauges. The brightness of all lights should be adjustable and all lights should be extinguishable with on-off switches. This light configuration would allow maximum flexibility for operating during daytime, nighttime, and blackout conditions.

2. **Problem:** The generator is somewhat difficult to pull start when it is cold. This problem is compounded by the tubular steel frame of the generator which interferes with pulling the starter rope straight upwards. Instead, one must pull the rope at a slight angle outwards and this reduces the force that can be exerted.

Violation of MIL-STD-1472C: Section 4.4(d)

Recommendation: Redesign the tubular steel frame so that it does not interfere with the human movements required for starting the generator.

3. **Problem:** The muffler is painted bright silver, which is tactically unsound.

Recommendation: Paint the muffler the same color as the rest of the generator.

4. **Problem:** If this generator is mounted on a command track, it will produce enough heat to raise the temperature inside the track.

Recommendation: Insulate the area directly underneath the generator if it is mounted on a command track.

6.1.3.4 Manufacturer A, 3 kW, 60 Hz Generator

The operator of this generator could not be identified. Thus, no ratings or comments are available.

6.1.3.5 Manufacturer C, 3 kW, 60 Hz Generator

6.1.3.5.1 Ratings Made By One Operator

a. Environment. The operator was satisfied with all aspects of the operational environment. He gave "Acceptable" ratings for the noise level of the generator for tactical operations, the noise level of the generator during operator maintenance, the vibration level, and the temperature level. He gave "About right" ratings for the daytime light levels near the operator's panel, and the nighttime light levels obtained by a red lens flashlight at the operator's panel during blackout conditions.

b. Indicator Lights. The operator gave "Adequate" ratings for all items relating to the indicator lights.

c. Gauges. The operator gave "Adequate" ratings for all items relating to the gauges.

d. Controls. The operator gave "Adequate" ratings for all items relating to the controls.

e. Power Connections. The operator gave "Adequate" ratings for all items relating to the power connections.

f. Equipment Location. The operator gave "Adequate" ratings for all items relating to equipment location, except the four pieces of equipment that were rated "Not Applicable": Emergency Stop-Run switch, Governor control, Fuel selector switch, and Storage compartments.

g. Workspace and Storage Space. The operator gave "Adequate" ratings for the amount of workspace within the acoustical enclosure, the amount of storage space provided for fuel cans, and the amount of storage space provided for grounding rods. The operator gave "Not Applicable" ratings for the following items: Platforms, walking spaces, footholds, and handholds for mounting generator to perform duties; Amount of storage space provided for tools, Amount of storage space provided for spare parts, and Amount of storage space provided for manuals.

h. Operational Procedures. The operator gave "Easy" ratings to all items in this section except "Start up generator manually." He rated this item as "Did Not Perform."

i. Maintenance Procedures. The operator gave "Easy" ratings for all items in this section, except those he rated "Did Not Perform." Apparently, the operator did not perform the following tasks: Replace lamps and fuses, Check batteries, Service batteries, Change engine oil, Check oil filter, and Replace oil filter. The operator also did not perform any task relating to unscheduled maintenance.

j. Operator's Manual. The operator stated that an operator's manual was not present with this generator.

k. Tools. No ratings were given for the adequacy of normally-issued tools to perform operator PMCS and to troubleshoot.

l. Trailer. The operator gave "Adequate" and "Very Adequate" ratings for all items relating to the trailer.

6.1.3.5.2 Comments Made By One Operator

No comments were made by this operator.

6.1.3.5.3 Ratings Made By One Driver

The driver gave "Very Easy" ratings for all items relating to the towability of the trailer. He failed to give any ratings for the design features of the trailer.

6.1.3.5.4 Comments Made By One Driver

No comments were made by this driver.

6.1.3.5.5 Analysis

Only one operator completed the questionnaire for this generator. He gave no adverse ratings to the generator and made no comments about it. Consequently, no human factors problems were identified.

6.1.3.6 Manufacturer D, 3 kW, 60 Hz Generator

This generator was not used on the field exercises during the test. Consequently, ratings and comments were not available from system operators.

6.1.3.7 Manufacturer C, 5 kW, 60 Hz Generator

6.1.3.7.1 Ratings Made By Twelve Operators

a. Environment. Operators generally gave "Acceptable" ratings to noise, vibration, temperature and daytime light levels near the generator. However, operators indicated that light levels near the generator during normal night operations were too low. Operators generally indicated that the light levels achieved by red lens flashlights during blackout conditions were adequate.

b. Indicator Lights. Operators generally gave "Adequate" ratings to the indicator lights, although there were several inadequate ratings with respect to brightness at night.

c. Gauges. In general, "Adequate" ratings were given to the gauges on the control panel. However, several "Inadequate" ratings were given to location of gauges, timeliness of information, and precision of the information.

d. Controls. "Adequate" ratings were generally given to controls.

e. Power Connections. "Adequate" ratings were generally given to power connections, although two operators gave "Inadequate" ratings in this area.

f. Equipment Location. Most aspects of equipment location received "Adequate" ratings. However, six operators gave "Inadequate" ratings to the configuration of the generators on the trailer and five operators gave "Inadequate" ratings to the location of the oil fill.

g. Workspace and Storage Space. Although operators generally gave "Adequate" ratings to workspace and storage space, several operators gave "Inadequate" ratings to the amount of storage space available for tools, spare parts, and manuals.

h. Operational Procedures. Operators generally gave "Easy" and "Very Easy" ratings to operational procedures both with and without MOPP clothing, although most indicated that they did not operate the generator while in MOPP clothing. One operator indicated that it was difficult to locate the generator in place.

i. Maintenance Procedures. Operators generally indicated that it was easy or very easy to perform PMCS, but that they did not perform unscheduled maintenance actions on the generator. A few operators indicated that it was also easy to perform PMCS in MOPP clothing, although most indicated that they had not performed PMCS while in MOPP gear. Two operators indicated difficulty in checking and changing the engine oil and oil filter. and one operator gave "Very Difficult" ratings to checking and servicing the batteries and radiator, and refueling, while wearing MOPP clothing.

j. Manual. Eleven of the twelve operators indicated that a manual was present with the generators. One operator indicated that he used it more than five times, seven indicated one to five times, and three said that they never used it. Although the manual generally received "Adequate" ratings, two "Very Inadequate" and one "Inadequate" ratings were given to the description of power connections; one "Very Inadequate" and one "Inadequate" rating were given to the description of cables; and two "Inadequate" ratings were given to the explanation of PMCS. Three operators indicated there was information which they could not find in the manual. Finally, out of nine operators who gave overall ratings to the manual, about half gave positive ratings in the areas of accuracy, comprehensiveness, and effectiveness and about half gave negative ratings in these areas.

k. Tools. Generally, "Adequate" ratings were given to tools, although two "Inadequate" ratings were given to tools for troubleshooting.

l. Trailer. Almost all of the ratings on the trailer were "Adequate" or "Very Adequate", although two operators gave "Inadequate" ratings in the areas of tire size and the power box. "Inadequate" ratings were given to the height of the chassis above the ground and the hook-up mechanism for the trailer.

6.1.3.7.2 Comments Made By Twelve Operators

a. Environment

1. One operator commented: Sound levels of the generator were low; that was good.

2. One operator commented: If you open the panels on the generator while it is running, it is too noisy for tactical purposes.

3. Two operators commented: There is not enough light to see the gauges and the circuit breaker at night. A panel light would help.

4. Two operators commented: There is no light near the fuel gauge.

5. One operator commented: The green indicator light on the control panel is somewhat too dim to see during the day.

6. One operator commented: At night one can see the indicator lights on the generator at a farther distance than one can hear it. This constitutes a light discipline problem for tactical operations.

b. Indicator Lights

1. Three operators commented: It is difficult to see the control panel on the rear generator because of the way it sits on the trailer. If it were turned 90° so that the control panel faced outward, there would be no problem.

2. Two operators commented: Lighting on the control panel is inadequate for an operator's use at night.

3. One operator commented: When the generator was sitting on a slope, the oil indicator light would sometimes come on even if there was enough oil.

c. Gauges

1. One operator commented: Having a fuel gauge was useful.
2. Two operators commented: It was somewhat of a problem having to climb up on the trailer to look at the fuel gauge, especially if you were wearing MOPP gear.
3. One operator commented: The gas gauge was not always accurate. We used time to determine when to refuel.
4. One operator commented: The voltage gauge should have more indicator points, rather than just going from 100 to 150 volts.
5. Two operators commented: The voltage controls were turned all the way up, but I could only obtain 110 VAC in my van from one generator and 118 VAC from the other generator.
6. One operator commented: There is no cycle meter.
7. One operator commented: An hour meter is needed.
8. One operator commented: A panel light is needed to see the control panel at night.

d. Controls

1. Two operators commented: The key needed to start the generator could be lost. A starter button would be better.
2. One operator commented: The screws on the panel over the battery compartment should be replaced with wing nuts.
3. One operator commented: Some of the knobs, like the fuel selector switch, were so easy to turn I did not know if they were working.

e. Power Connections

1. Five operators commented: Power cables had to be hooked up to the load terminals in the power junction box in a way that was different from how we hook up our military standard generators, i.e., we normally hook up on L_2 and L_3 , whereas on this generator we had to hook up on L_1 and L_0 for 120 VAC.
2. Two operators commented: It would be useful if there were a latch to hold up the power junction box cover when one is connecting cables to lugs.
3. One operator commented: Although it has not happened yet on this system, the power junction box on our military generators often becomes damaged because we connect and disconnect cables so many times. The lug nuts get stripped and damage occurs inside the box. Then we have to start hooking up directly to the generator.

f. Equipment Location

1. Five operators commented: It is difficult to get to the control panel of the rear generator because of the way it is positioned. Rotating it 90° so that the control panel faces outwards would help.
2. One operator commented: There is no problem reaching the control panel of the rear generator.
3. Four operators commented: The generator must be level before one can check the oil. If it is tilted toward the oil spout, oil will run out onto the trailer when one tries to check it.
4. Five operators commented: The drains for the oil and coolant are located such that the only way to drain the oil or coolant is to let the fluid drain onto the floor of the trailer. Drain hoses or holes in the bed of the trailer directly beneath the drains would solve this.
5. One operator commented: A funnel, which usually is not available, is needed to add oil to the generator because the oil fill is set too far inside.
6. Three operators commented: Refueling with a five-gallon gas can often results in spilled gas on the top of the generator because the gas can hits an overhead trailer support. This causes the spout to move. It would be better to have a side point for refueling the generator.

g. Workspace and Storage Space

1. Two operators commented: It would be useful to have a storage location for the manuals near the generator.
2. One operator commented: There is no storage space on the trailer for manuals or tools.
3. One operator commented: It would be useful to have a storage space for oil. We keep our manuals inside the van.
4. One operator commented: We keep manuals and supplies in our van. There is plenty of room for them there.
5. One operator commented: It was difficult to refuel the rear generator because of the canvas over the trailer and the camouflage net.
6. One operator commented: The strap holding the gas can in the middle storage position on the trailer was too short, and there wasn't enough room for it. You had to fight to get it off.

h. Operational Procedures

One operator commented: When I first checked the oil, about a pint spilled out before I got the cap back on. The generator was basically sitting level, with just a slight inclination.

i. Maintenance Procedures

1. Three operators commented: There is a problem checking the oil. If the generator is not level, oil will spill out from the spout as you check it. A dipstick would help.

2. One operator commented: Refueling was difficult, especially for a short operator. He has to climb up on the trailer to reach the fuel spout on top of the generator.

3. One operator commented: Fuel is sometimes spilled during refueling because the fuel can bumps against the trailer canvas support.

4. One operator commented: It is difficult to perform PMCS, such as checking battery, changing oil filter, and checking radiator, in MOPP IV because it is hard to see out of the mask.

j. Manual

1. Three operators commented: The manual did not contain information on how to hook-up the power cable to the terminal lugs.

2. One operator commented: The manual does not tell you enough about the generator. It does not tell you enough about the fuel tank, or how to remove the batteries.

3. One operator commented: The manual did not have a PMCS table in it.

4. One operator commented: Missing information included how long the generator will run on 4.3 gallons of gas, how to know when fuel tank is full, and how to hook up the power cable to the load terminal lugs.

k. Tools

1. One operator commented: The tools we normally have were adequate, but we really didn't use them on this generator.

2. Two operators commented: A screwdriver was used to open the side panel to check the oil and a crescent wrench was used to hook cables up to lugs. We have these in the van.

l. Trailer

1. Two operators commented: It is difficult to extend the safety leg under the rear portion of the trailer. We often had to dig out to make enough room so that it could be locked into position.

2. One operator commented: The cables have to be hooked up to the power box so many times that eventually the lugs strip. Putting a hock on the cable would help.

3. One operator commented: The sequence of hooking cable wires to lugs is different from that on military standard generators.

4. Two operators commented: The trailer jerks and bounces when it is towed down a hill because the wheels automatically lock up when pressure is applied to the tongue.

5. One operator commented: The electrical cable from the trailer does not connect to the towing vehicle very well. Difficulties in making the connection will probably cause it to wear out.

6. One operator commented: There is no crank or jack for raising or lowering the tongue of the trailer. You have to manhandle it to get it onto the trailer hitch, and this is a problem with units having women in them.

7. One operator commented: It is a little crowded in the area between the two generators.

m. Additional Comments

1. One operator commented: One good thing about these generators is that they ran 8 hours rather than just 4 hours like the regular Army generators.

2. One operator commented: Overall, I like them. Overall I would give them a B rating. I can go 8 hours on them. They don't have to be located way out in the woods, so if you have to make a night move, they are close.

3. One operator commented: It would be useful to have a dip stick for checking oil, to prevent the oil spilling out easily. Also, the oil drain is such that it will spill all over the trailer. I really liked them a lot especially the noise part.

4. One operator commented: I was very impressed with lack of noise and maintenance needed to keep the generator running. Fuel consumption was excellent; approximately 4 gal every 7 hours, compared to the old generator usage of 5 gal every 3-4 hours. Oil and coolant were never needed. We ran the generator 24 hours/day for 5 1/2 days, switching every 6-7 hours, with no problems in overheating and no breakdowns. No comparison to regular 5 KW generators: You don't have to wear ear plugs; you don't get headaches working around it because of the noise. In a tactical environment you can't beat it.

5. One operator commented: The silent aspect of the generators is a major factor. A normal 5 KW you can hear a mile and a half away.

6. One operator commented: They provided plenty of power; no bursts of power. They were easy to operate. Even if you had never seen a generator before, you could figure it out.

7. One operator commented: I like another type of generator better than these because the other type ran 20 some hours without refueling. The operators have to check it only once a day, so they have more time to perform other duties. With this generator, I have to tend to it 3 times a day since a full tank of fuel lasts only 8-10 hours. This generator has a fuel gauge; the other type doesn't. This generator has controls on the outside of the acoustical housing; the other type has controls inside the housing. Even so, I prefer the other type generator.

6.1.3.7.3 Ratings Made By Eight Drivers

Most drivers indicated that the generator/trailer was easy to tow and was adequate with respect to trailer characteristics. However, there were several "Difficult" ratings given to towing cross-country and a few "Inadequate" ratings on trailer characteristics like height of chassis above the ground, tire size, and the hook-up mechanism.

6.1.3.7.4 Comments Made By Eight Drivers

- a. Two drivers commented: The automatic brakes cause the trailer to jerk and bounce when going cross-country or downhill.
- b. One driver commented: Trailer lights cannot be seen during the day.
- c. One driver commented: The small tires make the trailer too close to the ground and make it difficult to lower the rear safety leg.
- d. One driver commented: The trailer is a lot lighter. It is easier for a female to move.
- e. One driver commented: The trailer does not stray all over the road and is easy to tow.

6.1.3.7.5 Analysis

Analysis of the preceding results led to the identification of human factors problems and the classification of these problems into the following critical and non-critical categories:

a. Critical Problems

1. Problem: The generator is started with a key rather than a push button or switch. Keys are easily lost, posing a potential problem of not being able to start the generator because of lost keys.

Recommendation: Replace key system with a push button or switch.

2. Problem: The labeling scheme for the lugs on this generator was not the same as that on military 5 KW generators, i.e. this generator required hook-up to L_1 and L_0 for 120 VAC, while military generators require hook-up to L_2 and L_3 . This created confusion among the operators.

Violation of MIL-STD-1472C: Section 5.5.1.2(f)

Recommendation: The labels on the generator lugs should be made consistent with the labeling scheme used to identify lugs on military generators.

3. Problem: Checking the oil is accomplished by taking the cap off of the oil fill and looking to see if the oil is near the rim of the fill spout. If the generator is tilted even slightly, oil will run out onto the floor of the trailer when the cap is removed.

Violation of MIL-STD-1472C: Section 4.4 (m)

Recommendation: Design generator so that oil can be checked with a dip stick.

4. Problem: The oil and coolant drains are located so low on the side of the generator that one cannot get a collection pan beneath them. Thus, the soldier must let oil and coolant drain onto the trailer bed when changing these fluids.

Violation of MIL-STD-1472C: Section 4.4 (m)

Recommendation: Attach drain hoses to the oil and coolant drain valves, and extend the hoses beyond the edge of the trailer to a drain pan.

5. Problem: The safety leg under the rear of the trailer is too long and cannot be lowered until the ground is dug out beneath it. In rocky terrain it becomes nonfunctional.

Violation of MIL-STD-1472C: Section 5.13.6.1

Recommendation: Shorten the safety leg under the trailer or design it to be more adjustable.

b. Non-critical Problems

1. Problem: There is no panel light than can be turned on or off so that operators can check the operator's panel at night. Also tactical light discipline cannot be adhered to because there is no way to turn off or cover the indicator lights on the operator's panel.

Violations of MIL-STD-1472C: Sections 5.1.1.5 and 5.2.1.2.1

Recommendation: Use external white lights on the operator's panel and low luminance, integral red lights for all gauges. The brightness of all lights should be adjustable and all lights should be extinguishable with on-off switches. This light configuration would allow maximum flexibility for operating during daytime, nighttime, and blackout conditions.

2. Problem: It is somewhat difficult to get to the operator's panel on the rear generator because of its location in the center of the trailer.

Violations of MIL-STD-1472C: Sections 5.2.1.4.1 and 5.4.1.3.3

Recommendation: The generator should be rotated 90° so that the operator's panel is accessible from the side of the trailer.

3. Problem: There is no storage location on the trailer for manuals and spare parts (oil filters, oil cans, etc.) and tools.

Violation of MIL-STD-1472C: Section 5.7.1.3.4

Recommendation: Storage space should be provided for manuals, tools, spare parts, fire extinguishers, grounding rods, and other maintenance items.

4. Problem: The operator's manual is extremely cursory and has no information on how to hook up cables and contains no PMCS table.

Recommendation: Add information to manual concerning procedures for hooking up power cables to the generator and procedures for performing preventative maintenance checks and services.

5. Problem: The automatic brakes on the trailer cause it to jerk and bounce when being towed cross-country or downhill.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: Redesign the brake system to reduce the amount of bouncing and jerking when the trailer is pulled cross-country or downhill.

6.1.3.8 Manufacturer D, 5 kW, 60 Hz Generator

6.1.3.8.1 Ratings Made By Eight Operators

a. Environment. Operators were generally satisfied with the noise, vibration and temperature levels of the generator during normal operations, but three operators indicated that the noise level was somewhat too high when the doors were open for maintenance. While operators indicated that light levels during the day were adequate, three operators gave ratings of "Too Low" and three operators gave ratings of "Much Too Low" to light levels at the operator's panel at night. "Adequate" ratings were given to the light levels achieved using a red lens flashlight.

b. Indicator Lights. Generally, operators gave "Adequate" ratings to indicator lights, although two "Inadequate" and two "Very Inadequate" ratings were given to the brightness of the lights at night.

c. Gauges. Gauges generally received "Adequate" ratings, although three "Inadequate" and two "Very Inadequate" ratings were given to the brightness of the gauges. Also, under the Indicator Light section two "Very Inadequate" ratings were given to the fuel gauge.

d. Controls. Controls generally received "Adequate" ratings, although one "Inadequate" rating was given to accessibility and one "Very Inadequate" rating was given to the phase switch.

e. Power Connections. The power connections were rated "Adequate" by most operators, although one operator gave "Inadequate" ratings to the size and spacing of the lugs, and the ease of connecting cables, and one operator gave a "Very Inadequate" rating to the junction box.

f. Equipment Location. Generally, "Adequate" ratings were given to the location of equipment, although two "Inadequate" ratings were given to storage compartments, two "Very Inadequate" and one "Inadequate" ratings were given to the configuration on the trailer, and one "Very Inadequate" and two "Inadequate" ratings were given to the location of the fuel fill.

g. Workspace and Storage Space. Operators generally gave "Inadequate" ratings to the amount of storage space available. Three "Very Inadequate" and three "Inadequate" ratings were given to storage space for fuel cans; and three "Very Inadequate" and two "Inadequate" ratings were given to storage space for manuals. Four "Inadequate" ratings were also given to storage space for tools and spare parts.

h. Operational Procedures. Operators generally rated operating the generator as "Easy", both with and without MOPP clothing.

i. Maintenance Procedures. The operators indicated that they did not perform many of the maintenance tasks. Those that they did perform were generally rated as "Easy", although three operators indicated that it was difficult to replace lamps and fuses.

j. Manual. Seven of the operators indicated that a manual was present with the generator. Four indicated that they used it from one to five times and three indicated that they used it more than five times. Most operators gave "Adequate" or "Don't Know" ratings to questions about the manual, although two operators gave "Very Inadequate" and "Inadequate" ratings to most questions about the manual. Four operators indicated that information was missing from the manual.

k. Tools. No tools were issued. Operators gave "Adequate" or "Not Applicable" ratings to questions about tools.

l. Trailer. Most operators gave "Adequate" and "Very Adequate" ratings to the trailer, although two operators gave "Inadequate" ratings to the overall size and weight of the trailer. Two operators gave "Very Inadequate" ratings to aspects of the power box, and three operators gave "Inadequate" ratings to fuel storage.

6.1.3.8.2 Comments Made By Eight Operators

a. Environment

1. One operator commented: The noise levels with the baffles and doors open are somewhat too high.

2. Five operators commented: There is no panel light to illuminate the gauges and controls at night. If you use a flashlight, you have only one free hand for performing other tasks.

b. Indicator Lights

1. One operator commented: There should be a way to turn indicator lights out when in blackout conditions.

2. Three operators commented: Panel lights are needed to see gauges and controls on the panel.

c. Gauges

1. Two operators commented: It is difficult to see the gauges at night.

2. Five operators commented: A fuel gauge is needed so that the operator can monitor fuel level.

3. One operator commented: The oil pressure gauge can only be seen if a panel is removed.

d. Controls

1. Two operators commented: Most controls, such as the circuit breakers, are accessible only by removing a panel; they need to be on the outside of the system.

2. One operator commented: I did not know what the phase switch was.

e. Power Connections

1. One operator commented: The terminal lugs in the junction box need to be larger and spread out more so that several cables can be connected to them.

2. One operator commented: Since there is a junction box on only one trailer of a pair of generator/trailers, you have no way of providing power if the generator with the junction box has to be removed for maintenance.

3. Three operators commented: The cable hocks which plug into the generator are plastic and will not hold up in the field. They should be replaced with metal ones.

4. One operator commented: It is difficult to hook cables up to the junction box while in MOPP IV. Perhaps clamps for securing the cable to the lugs would be easier to operate than nuts.

f. Equipment Location

1. Three operators commented: There is no storage compartment.

2. One operator commented: Fuel fill is inside of panel door. It should be on outside so one does not have to take off the door to get to it and raise the noise level.

3. One operator commented: The location of the fuel fill down inside the housing makes it somewhat difficult to fill and causes spillage of fuel.

4. One operator commented: Oil fill is slanted and results in spillage of oil. It needs to be straightened to a more upright position.

5. One operator commented: There is no way for us to get to the choke or governor control. We should be able to adjust the system for proper frequency and voltage output.

g. Workspace and Storage Space

1. Two operators commented: The three fuel cans are located in the front near the trailer hitch, and it is rather difficult to get to them and retrieve them.

2. Two operators commented: Fuels cans should be mounted on fenders where they would be more accessible.

3. One operator commented: The two middle brackets for storing fuel cans are too close, making it difficult to tighten or loosen the tie down straps.

4. One operator commented: There should be storage for 2 or 3 more fuel cans.

5. Three operators commented: There is no storage compartment for tools, manuals, and spare parts.

6. One operator commented: It is difficult to work on the generator because of the lack of room inside the housing.

h. Operational Procedures. One operator commented: It was easy to operate the generator. I didn't have to check the fuel level every four hours as with my old 5 KW generator.

i. Maintenance Procedures

1. One operator commented: To check the oil, one must remove a panel. This causes the noise level to rise. To simplify the process, the oil gauge should be located where the other gauges are.

2. Two operators commented: Replacing lamps and fuses, and troubleshooting failures, are difficult because the generator is enclosed in a housing.

3. Two operators commented: It is difficult to perform maintenance in MOPP gear.

4. Two operators commented: PMCS was easy enough to do in MOPP gear.

5. One operator commented: Overall, operator maintenance is not bad, although better ways of refueling and adding oil would help. Being able to fuel from a 55-gallon drum would be easier.

j. Manual

1. Three operators commented: The manual did not have enough general information about the generator, such as capacity of the fuel tank and how long it would run on a tank of gas.

2. Two operators commented: The manual did not have information telling the operator how to troubleshoot in event of failure.

3. One operator commented: There was no PMCS table.

4. One operator commented: The manual did not indicate how to hook up cables to the junction box.

k. Tools

1. One operator commented: No tools were issued.

2. One operator commented: We already had tools.

l. Trailer

1. One operator commented: We normally have two 5 KW generators on a trailer but these are too large to have two per trailer.

2. One operator commented: The truck was heavy and hard to drive on the sand.

3. One operator commented: The trailer is too short for the generator.

4. One operator commented: Fuel cans should be mounted on the fenders.

5. Two operators commented: Each trailer should have a junction box.

6. One operator commented: I have always been displeased with the Army's junction boxes. The lugs are hard to use.

m. Additional Comments: One operator commented: The generator is very good; no problem putting a load on it, and it could handle any load we put on it. Very quiet - which would be great on the battlefield. Durability and how long it can run is unbelievable. When you can do your mission and leave the generator alone for 10 hours, it's great. That's what we need. We can't be checking generators every 4 hours to see that they don't run out of fuel. We ran one generator for 16 hours continuously before it died. Everything is easy to handle. It is easy to start in cold weather and hot weather; we've experienced them both out here. It is very quick. The only problem we had was with the fuses; it took entirely too long to replace a fuse for a fan. Experience on this type of generator might alleviate a few problems like this. With experience on the generator, we'll know how to troubleshoot from now on.

6.1.3.8.3 Ratings Made By Three Drivers

The drivers generally gave "Adequate" and "Very Adequate" ratings to the trailer. However, one operator gave "Inadequate" ratings to towing the generator on gravel roads at speeds exceeding 25 mph, and to towing the generator cross-country.

6.1.3.8.4 Comments Made By Three Drivers

One driver commented: The generator is very heavy. Using a CUCV we had a hard time getting through deep sand, even with 4-wheel drive. However, the generator handled nicely on paved roads, even up to 50 mph. The generator sits well on this type of trailer.

6.1.3.8.5 Analysis

Analysis of the preceding results led to the identification of human factors problems and the classification of these problems into the following critical and non-critical categories:

a. Critical Problems

1. Problem: A side panel must be removed in order to gain access to the main circuit breakers and the fuel fill. A different panel must be removed to see the oil pressure gauge. These actions compromise the noise reduction function of the housing and are cumbersome and time-consuming procedures.

Violations of MIL-STD-1472C: Sections 5.9.4.5 and 5.2.1.4.2

Recommendation: The circuit breaker and fuel fill should be moved to the outside of the housing. The oil pressure gauge should be located with the other gauges.

2. Problem: The absence of a fuel gauge makes it difficult to estimate fuel level, especially across shift changes.

Violation of MIL-STD-1472C: Section 5.2.1

Recommendation: A fuel gauge should be installed on the operator's panel.

3. Problem: The fact that only one generator of a pair has a junction box creates a situation where the second generator of the pair is useless if the generator with the junction box has to be removed for maintenance.

Violation of MIL-STD-1472C: Section 4.4 (m)

Recommendation: Install a junction box on each generator trailer.

4. Problem: The plastic hocks on the power cable are likely to be easily damaged in a military environment.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: Replace the plastic hocks with metal or rubber ones.

b. Non-critical Problems

1. Problem: The brightness of the lights on the operator's panel compromises tactical light discipline at night.

Violations of MIL-STD-1472C: Sections 5.1.1.5 and 5.2.1.2.1

Recommendation: Use external white lights on the operator's panel and low luminance, integral red light for all gauges. The brightness of all lights should be adjustable and all lights should be extinguishable with on-off switches. This light configuration would allow maximum flexibility for operating during daytime, nighttime, and blackout conditions.

2. Problem: There is no storage location on the trailer for manuals, spare parts, and tools.

Violation of MIL-STD-1472C: Section 5.7.1.3.4

Recommendation: Storage space should be provided for manuals, tools, spare parts, fire extinguishers, grounding rods, and other maintenance items.

3. Problem: It is somewhat difficult to remove the fuel cans from their location on the front of the trailer.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: Relocate fuel can storage brackets to trailer fenders so that fuel cans are more accessible.

4. Problem: The manual did not contain sufficient operator-related information, such as fuel tank capacity, rate of fuel use, PMCS charts, and procedures for connecting power cables to the lugs.

Recommendation: Add information to the manual concerning fuel tank capacity, fuel usage rate, PMCS, and power cable hook-up.

5. Problem: The generator/trailer is very heavy and difficult to pull through sand, even with a 4-wheel drive vehicle.

Recommendation: Reconsider whether the trailer is adequately designed for this generator.

6.1.3.9 Manufacturer E, 5 kW, 60 Hz Generator

6.1.3.9.1 Ratings Made By Eight Operators

a. Environment. All of the operators rated the noise, vibration, and temperature levels near the generator as "Acceptable." Daytime light levels were rated as "About Right." Nighttime light levels, however, were rated as "Somewhat too high" by three operators and as "Somewhat too low" by one operator. Two operators indicated that panel lights were needed on the operator's panel. Operators indicated that light levels achieved at night using a red lens flashlight were about right for operating the generator.

b. Indicator Lights. Operators generally gave "Adequate" and "Very Adequate" ratings to the indicator lights.

c. Gauges. Operators generally gave "Adequate" and "Very Adequate" ratings to the gauges, although one operator gave "Very Inadequate" ratings to the fuel gauge, timeliness of information from the fuel gauge, and precision of information from the gauge.

d. Controls. Operators generally gave "Adequate" ratings to the controls.

e. Power Connections. Operators generally gave "Adequate" ratings to power connections, although one "Inadequate" rating was given to spacing between the terminal lugs and one to the ease of connecting cables.

f. Equipment Location. Although operators generally gave "Adequate" ratings to equipment location, three "Inadequate" ratings were given to the location of the fuel fill. One "Inadequate" rating was given to the location of each of the following: batteries, oil fill, and coolant fill. One "Very Inadequate" rating was given to the location of the fuel gauge.

g. Workspace and Storage Space. Although most ratings given to space were "Adequate", two "Very Inadequate" and one "Inadequate" ratings were given to storage space for fuel cans; one "Very Inadequate" and one "Inadequate" ratings were given to storage space for manuals; one "Very Inadequate" rating was given to storage space for spare parts; and one "Inadequate" rating was given to amount of workspace.

h. Operational Procedures. Operators generally indicated that it was easy to operate the generator, although one operator gave "Difficult" ratings to operating it while in MOPP gear.

i. Maintenance Procedures. Operators generally indicated that it was easy to perform PMCS on the generator, although one operator indicated that it was very difficult to check and service the batteries, and check the engine oil. Several operators indicated that it was difficult to perform PMCS while wearing MOPP gear. Most operators indicated that they did not perform unscheduled maintenance actions; the remaining operators did not indicate difficulty performing such maintenance.

j. Manual. Five operators indicated that a manual was present with their generator and three indicated a manual was not present. The five indicated that they had used the manual from one to five times. Most of their ratings of the manuals were in the "Adequate", "Very Adequate" and "Easy" categories. However, the overall description of the generator and the description of the operator's control panel received one "Inadequate" rating, and the understandability of the illustrations received one "Very Difficult" rating. The manual was generally rated as accurate, comprehensive and effective.

k. Tools. Operators generally gave "Adequate" ratings to tools, with the exception of the operator who was also a maintenance supervisor. He gave "Very Inadequate" ratings to the tools.

l. Trailer. Characteristics of the trailer received "Adequate" and "Very Adequate" ratings, with two exceptions: Fuel storage received one "Inadequate" and one "Very Inadequate" ratings, and Height of Chassis above ground received one "Inadequate" rating.

6.1.3.9.2 Comments Made By Eight Operators

a. Environment

1. Six operators commented: Lights on the operator's panel are too bright for tactical light discipline at night. A means needs to be devised that would allow them to be turned off or covered up at night.

2. One operator commented: You need a flashlight to read the fuel gauge.

b. Indicator Lights

1. Two operators commented: You need a switch to turn off the indicator lights in order to maintain light discipline.

2. One operator commented: A light is needed by the fuel gauge.

c. Gauges

1. Two operators commented: The fuel gauge should be located elsewhere; you have to get up on the trailer to see it.

2. One operator commented: The fuel gauge sticks at times; you have to thump it to get a correct reading.

3. Two operators commented: The gauges went out on both sets of our generators. On one set the amps and voltage gauges went out, and on the other set the voltage gauge went out.

d. Controls. No comments were made about controls.

e. Power Connections

1. One operator commented: The terminal lugs need to be spaced farther apart in order to get tools in to tighten or loosen the lug nuts.

2. One operator commented: There are no convenience outlets on the generator.

f. Equipment Location

1. Three operators commented: It is difficult to fill the fuel tank with a 5-gallon can because the generator cover prevents one from tipping the fuel can up very far.

2. One operator commented: The battery is difficult to get to; you have to raise the cover to get to it.

3. One operator commented: Access doors are needed in the generator cover so that you don't have to lift the whole cover to check the oil or battery.

4. One operator/maintenance supervisor commented: Checking oil and water and maintaining the generator in the field are difficult because you sometimes have to cut off overhead tree branches in order to raise the cover to gain access to the generator. Also, one maintenance task is to clean out sediment from the fuel tank. But you have to lift the cover up and take the tank out to do it. It has a drain cock, but you can't get through from either side of the front to get to it; a skid plate is in the way. So you have to take the tank out and thus you have to take the whole baffle off.

5. One operator commented: Because of the way the two generators are mounted, you have to climb onto the trailer to start the rear one. If the rear generator were turned around and the exhaust were directed upward, the control panel would be more accessible. That would require longer cables to the junction box.

g. Workspace and Storage Space

1. One operator commented: We had spaces for four fuel cans, but we should have space for eight.

2. One operator commented: We need storage space for at least six fuel cans.

3. Two operators commented: There is a need for a lockable storage box on the trailer in which tools, spare parts, and manuals can be stored.

4. One operator commented: The space between the generators is not sufficient; it's a little close.

h. Operational Procedures

1. One operator commented: Anything is difficult in MOPP gear, but I did not have to operate the generator in MOPP gear on this exercise.

2. One operator commented: It was easy to operate the generator in regular BDU's. Adjustment with MOPP would be minimal.

3. One operator commented: MOPP gear really had no effect on performing the tasks with the generator.

i. Maintenance Procedures

1. Two operators commented: It is difficult to check the batteries and oil because of the need to raise the whole cover.

2. One operator commented: Vegetation such as tree branches sometimes interferes with raising the cover to perform maintenance. A chain or piston cylinder would be useful to prevent the cover from falling all the way backward when it is raised up for maintenance.

3. One operator commented: The problem with MOPP IV is with trying to see; also, the rubber boots and gloves. It makes everything about twice as hard.

4. One operator commented: Refueling was easy enough to do. Just use a five-gallon can. It is very accessible.

j. Manual

1. One operator commented: The manual did not have enough detail; it didn't tell me what I needed to know. But I cannot think of any examples.

2. One operator commented: The pictures and illustrations were too dark; I could not make them out.

3. One operator/maintenance supervisor commented: I abstracted from the manual and passed on to the operators a list of checks and services.

4. Two operators commented: Our manual disappeared. We needed it to know what we were doing although the checklist we received from the maintenance supervisor enabled us to operate it O.K.

5. We didn't use the manual because the generator ran excellently.

k. Tools

1. Two operators commented: We had no tools for the generator, but we didn't need any.

2. One operator/maintenance supervisor commented: The tools we normally have are English, but we need metric tools for this generator. Tools that we need are a 3/8-inch drive set, a metric open-end box wrench set, and a half-inch drive set. These are for maintaining it. Also, an operator would need some tools for checking batteries, fuel lines, and water hoses. Maybe a basic issue of screwdriver, wrench, sledgehammer; something of this nature.

l. Trailer

1. One operator commented: The chassis is too high off of the ground to be towed by a pick-up. The trailer is too heavy, it ripped the rear off the pick-up.

2. One operator commented: The wheel on the trailer tongue will fall down if you hit a slight bump. You have to tie it up with a rope to hold it in place.

3. One operator commented: The trailers have only 5-gallon fuel cans; there should be a tank in the trailer to avoid having to add fuel every eight hours.

4. One operator commented: The fuel tank holds only 7 1/2 gallons. Sometimes it would be useful to have an outside auxiliary fuel supply. It would be helpful to have a fuel selector valve within the fuel system so fuel could be drawn from a 55-gallon drum with a hose.

m. Additional Comments

1. One operator commented: The good thing about the generator is that it is quiet. There are really no dislikes with the limited use I have had with them.

2. One operator commented: They get good fuel economy. They ran 16 hours on 5 gallons of fuel. We refuel at switchover every 12 hours.

3. One operator commented: It was very reliable, quiet, and easy to start. It ran for 10 hours just great. I had no problems with it.

6.1.3.9.3 Ratings Made By Two Drivers

The drivers gave "Adequate" and "Easy" ratings to towing the generator.

6.1.3.9.4 Comments Made By Two Drivers

One driver commented: There was no difference between these trailers and the old ones.

6.1.3.9.5 Analysis

Analysis of the preceding results led to the identification of human factors problems and the classification of these problems into the following critical and non-critical categories:

a. Critical Problems

1. Problem: The lugs are too close together, making it difficult to hook up more than one cable.

Violation of MIL-STD-1472C: Section 4.4(d)

Recommendation: Space the lugs farther apart on the generator.

2. Problem: The fuel fill is located inside the acoustical housing. This makes it difficult to refuel the generator.

Violation of MIL-STD-1472C: Section 4.4(d)

Recommendation: Extend the neck of the fuel fill so that it sticks out from under the housing.

3. Problem: The tools required for maintaining the generator are metric, whereas most tools in the Army inventory are sized in the English system of measurement.

Recommendation: Issue metric tools for maintenance of the system.

4. Problem: There was space for only four fuel cans on the trailer. Operators need six or more cans so they will have an adequate reserve if the fuel truck is detained.

Recommendation: Increase the storage space on the trailer so that six fuel cans can be stored.

5. Problem: Performing preventative maintenance on the generator requires raising the whole housing which covers the generator. This is time consuming and awkward, particularly if there is anything overhead such as tree branches or trailer canvas supports. Also, there is no means of securing the housing in its upright position when performing maintenance.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: Design several doors into housing to allow easier access to the generator, or install a positive lock system to hold the housing in the "opened" position.

6. Problem: The generator/trailer is too heavy to be pulled by a pick-up. In one instance, the rear section of a pick-up was damaged.

Violation of MIL-STD-1472C: Section 4.9

Recommendation: Place warning labels on trailer to indicate that the generator is to be towed only by vehicles meeting given specifications, or redesign generator/trailer so that it can be towed by a pick-up.

b. Non-critical Problems

1. Problem: Lights on the operator's panel are too bright for tactical light discipline at night. In the field, operators taped pieces of cardboard over the panel to maintain light discipline at night.

Violation of MIL-STD-1472C: Section 5.2.1.2.1

Recommendation: Use external white lights on the operator's panel and low luminance, integral red lights for all gauges. The brightness of all lights should be adjustable and all lights should be extinguishable with on-off switches. This light configuration would allow maximum flexibility for operating during daytime, nighttime, and blackout conditions.

2. Problem: There is no storage location on the trailer for securing manuals, spare parts, and tools.

Violation of MIL-STD-1472C: Section 5.7.1.3.4

Recommendation: Storage space should be provided for manuals, tools, spare parts, fire extinguishers, grounding rods, and other maintenance items.

6.1.3.10 Manufacturer A, 10 kW, 60 Hz Generator, Modified

6.1.3.10.1 Ratings Made By Five Operators

a. Environment. The operators generally gave "Acceptable" ratings to noise levels with baffles and doors closed, vibration levels, temperature levels, and daytime light levels. They generally indicated that noise levels when the baffles and doors were open for maintenance were somewhat too high, that nighttime light levels were somewhat too low or much too low, and that nighttime light levels with a red lens flashlight were inadequate.

b. Indicator Lights. The operators generally gave "Adequate" and "Very Adequate" ratings for the indicator lights. However, two operators gave "Inadequate" ratings for the brightness of the indicator lights at night.

c. Gauges. The gauges generally received "Adequate" and "Very Adequate" ratings from the operators.

d. Controls. The controls generally received "Adequate" and "Very Adequate" ratings from the operators.

e. Power Connections. Although the power connections generally received "Adequate" and "Very Adequate" ratings, spacing between ports and accessibility of power connections each received an "Inadequate" rating, and the ease of connecting cables received two "Inadequate" ratings.

f. Equipment Location. The locations of various components generally received "Adequate" and "Very Adequate" ratings. However, the location of the oil fill received two "Very Inadequate" and three "Inadequate" ratings. Also, the locations of the choke and governor controls each received one "Inadequate" rating.

g. Workspace and Storage Space. There was a fair amount of variability in the ratings given to workspace and storage space with the ratings being distributed across all of the categories in the questionnaire. Among the negative ratings were two "Inadequate" ratings for the amount of storage space for spare parts, a "Very Inadequate" and an "Inadequate" rating for manuals, and an "Inadequate" rating for the amount of storage space for fuel cans and tools.

h. Operational Procedures. The operators generally gave "Easy" and "Very Easy" ratings to operational procedures and generally indicated that they did not operate the generator while wearing MOPP clothing.

i. Maintenance Procedures. The operators generally gave "Easy" and "Very Easy" and "Not Applicable" ratings to various maintenance procedures, and generally indicated that they did not perform maintenance on the generator while wearing MOPP gear. However, checking and changing the engine oil received one "Very Difficult" and two "Difficult" ratings. Troubleshooting failure to start received one "Difficult" rating and troubleshooting failure to provide power received a "Very Difficult" rating.

j. Operator's Manual. All of the operators indicated that they did not have a manual with the generator.

k. Tools. The ratings given for tools were generally "Adequate", "Don't Know", or "Not Applicable."

l. Trailer. The trailers generally received "Adequate" and "Very Adequate" ratings. However, fuel storage received two "Very Inadequate" ratings, and the following received one "Inadequate" rating each: hook-up mechanism, location of power box on trailer, suitability of power box for general use, labeling of lugs, size of lugs, lug connections, and the protective cover over the lugs.

6.1.3.10.2 Comments Made By Five Operators

a. Environment

1. Four operators commented: It is difficult to check and add oil at night even with a red lens flashlight. You cannot see where things are, or where the oil is on the dipstick.

2. Two operators commented: It was hard to add oil to the generator from a five-gallon can of oil, especially at night.

3. One operator commented: At night you can see the shapes of things but you really can't tell if you are connecting up the cables; you need to be able to see the cable and ground hook-up better.

b. Indicator Lights. One operator commented: The indicator lights were fine at night, except that if you had to fix something on the generator during blackout conditions there was no light to help you see.

c. Gauges. One operator commented: The gauges are not bright enough at night; you need a flashlight to see them properly.

d. Controls. One operator commented: It is difficult to use the choke while starting the engine because you have to walk around the generator to get to it.

e. Power Connections

1. One operator commented: It is difficult to connect up power cables because the lugs are too close together and the nuts are too big for a normal wrench.

2. One operator commented: The switch box on the trailer needs to be redesigned so that the lugs are easier to get to. There should be a way to fasten the lid open when connecting a cable to the lugs.

f. Equipment Location. Three operators commented: It is difficult to add oil because the baffles must be removed in order to get to the oil fill.

g. Workspace and Storage Space

1. One operator commented: There is no storage space for manuals.

2. One operator commented: The two storage boxes on the trailer need to be larger.

h. Operational Procedures. No comments.

i. Maintenance Procedures. One operator commented: It is very difficult for the operator to do any troubleshooting. It is usually beyond the operator's capabilities.

j. Operator's Manual. One operator commented: A manual did not come with the generators.

k. Tools

1. One operator commented: Operators had no tools or authorization to work on the generator except to change oil and refuel.

2. One operator commented: No special tools came with the generator set.

l. Trailer

1. Three operators commented: The trailer itself was fine.

2. One operator commented: The power hook-up is on the side of the generator; it would be better to have it on the front of the generator so that it would be more accessible.

3. One operator commented: The labels on the cable wires are inadequate because they get torn off and then it is hard to know which wire to hook up to which lug. The lug nuts themselves are very hard to turn because of their size. And the lug connections are not that good because the cables may move even though you have put them on very tight.

4. One operator commented: The cover on the switch box is a nuisance.

5. One operator commented: Because we are not allowed to transport fuel cans with the trailer, it is difficult to haul fuel for the generator. We have to depend on another vehicle.

6. One operator commented: A safety notice told us not to haul fuel cans on the trailers. But sometimes the trailers are the only place where we have room to haul them.

6.1.3.10.3 Ratings Made By Four Drivers

The drivers generally gave "Easy" and "Very Easy" ratings to towing the trailer, and gave "Adequate" and "Very Adequate" ratings to trailer characteristics.

6.1.3.10.4 Comments Made By One Driver

One driver commented: The trailer performed well and caused no major problems.

6.1.3.10.5 Analysis

Analysis of the preceding results led to the identification of human factors problems and the classification of these problems into the following critical and non-critical categories:

a. Critical Problems

Problem: There is not enough space between the lugs on the switch box to hook up several power cables simultaneously. Also, no lug wrench was available for tightening and loosening the lug nuts.

Violation of MIL-STD-1472C: Section 4.4(d)

Recommendation: Space the lugs farther apart on the switch box and provide the generator with a lug wrench.

b. Non-Critical Problems

1. Problem: The gauges are not lit well enough for nighttime viewing.

Violation of MIL-STD-1472C: Section 5.2.1.2.1

Recommendation: Use external white lights on the operator's panel and low luminance, integral red lights for all gauges. The brightness of all lights should be adjustable and all lights should be extinguishable with on-off switches. This light configuration would allow maximum flexibility for operating during daytime, nighttime, and blackout conditions.

2. Problem: There is no way to secure the switch box cover in the "opened" position when hooking up power cables.

Violations of MIL-STD-1472C: Sections 4.4(d) and 4.4(m)

Recommendation: Provide a latch for securing the switch box cover in the "opened" position to facilitate the hook-up of power cables.

3. Problem: The choke is on the rear of the generator, away from the operator's panel, making it somewhat awkward to start the generator.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: Relocate choke to operator's panel.

4. Problem: The necessity to open the noise-reducing baffles on the generator makes it difficult to check and add oil to the generator, especially at night when blackout conditions are in effect. The baffles are rather large and cumbersome, and the amount of room available when they are opened is limited. Thus, performing maintenance tasks such as adding oil from a five-gallon can is rather difficult.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: Design oil fill so that oil can be checked and replenished without having to remove acoustic baffles.

6.1.3.11 Manufacturer D, 10 kW, 60 Hz Generator

6.1.3.11.1 Ratings Made By Seven Operators

a. Environment. The operators generally gave "Acceptable" ratings to the noise, vibration, temperature, and light levels near the generator. However, one operator indicated that light levels at night were somewhat too high, while two operators indicated that they were too low, even when using a red lens flashlight.

b. Indicator Lights. The operators generally gave "Adequate" and "Very Adequate" ratings to the indicator lights, although a few "Inadequate" and "Very Inadequate" ratings were given by several operators.

c. Gauges. The operators generally gave "Adequate" and "Very Adequate" ratings to the gauges, although several operators gave a few "Inadequate" and "Very Inadequate" ratings to the gauges.

d. Controls. Generally, "Adequate" and "Very Adequate" ratings were given to controls, although two "Inadequate" ratings were given to spacing and accessibility, and one "Inadequate" rating was given to size and shape. Also, labeling received one "Very Inadequate" rating.

e. Power Connections. All of the operators but one gave "Adequate" or "Very Adequate" ratings to power connections. The one exception gave a "Very Inadequate" rating to spacing between the ports and an "Inadequate" rating to the ease of connecting cables.

f. Equipment Location. Although the ratings given to equipment location were generally positive, there was a fair amount of variability among the ratings. Three component locations each received two or more "Inadequate" or "Very Inadequate" ratings; these were the locations of the gauges, batteries, and fuel fill.

g. Workspace and Storage Space. Although operators generally gave "Adequate" ratings to workspace and storage space, three operators gave "Inadequate" and "Very Inadequate" ratings to storage space.

h. Operational Procedures. The operators generally gave "Easy" or "Very Easy" ratings to operational procedures without MOPP gear, although one operator gave a "Very Difficult" rating to locating the generator in place. Most of the operators did not operate the generator in MOPP gear. Of those ratings that were given for MOPP gear conditions, most were "Easy" or "Very Easy" with one "Difficult" rating being given to locating the generator in place, preparing it for transport, and transporting it.

i. Maintenance Procedures. The operators generally gave "Easy" and "Very Easy" ratings to PMCS and most indicated that they did not perform unscheduled maintenance actions. However, one operator gave a "Very Difficult" rating to replacing lamps and fuses, another operator gave a "Difficult" rating to refueling the generator, and two operators gave "Difficult" ratings to troubleshooting the failure of the generator to start.

j. Operator's Manual. Four operators indicated that they had a manual with their generator and three indicated that they did not. Of the four, one indicated he never used the manual, two indicated they used it one to five times, and one indicated that he used it more than five times. The ratings of the manual tended to be positive, although the explanations of PMCS and troubleshooting received several "Inadequate" and "Very Inadequate" ratings. Single "Inadequate" ratings were given to the table of contents, the index, overall organization, the description of control panel, and the description of other indicators and controls. Two operators indicated that there was information missing from the manual. Finally, one operator indicated that it was difficult to understand the manual and rated it as marginally accurate, incomplete, and ineffective. The other three operators rated it generally as "Accurate", "Comprehensive" and "Effective."

k. Tools. Operators gave "Adequate" and "Very Adequate" ratings to the trailer in all areas but two: Fuel storage (which received two "Inadequate" and one "Very Inadequate" ratings) and design features for mounting the trailer safely (which received two "Inadequate" ratings).

6.1.3.11.2 Comments Made By Seven Operators

a. Environment

1. One operator commented: Nighttime light levels at the operator's panel are too high for maintaining light discipline.

2. One operator commented: Operator panel lights are needed so the gauges can be read at night. The lights should be compatible with blackout conditions; i.e., they should be able to be covered or be switched on and off like the lights on military standard generators.

3. One operator commented: If you want an accurate reading from a gauge at night, you have to take the side panel off because the glass window reflects the flashlight beam. But when you do this, you have all of that noise from the diesel engine.

b. Indicator Lights. All of the comments in this section were actually about gauges and controls and therefore are listed under those headings.

c. Gauges

1. Four operators commented: The oil pressure gauge can only be seen by removing a side panel. It needs to be located where it can be seen easily with the rest of the gauges.

2. One operator commented: It is difficult to see the gauges if the glass insert in front of the control panel fogs up. If this occurs, you have to remove the side cover in order to see the gauges.

3. One operator commented: The panel needs to be redesigned to incorporate oil, temperature, frequency, hours, etc. in one panel assembly that is accessible without having to take a side panel off.

4. One operator commented: When you have to take the side panel off to see the gauges, you are losing time. Sometimes you need to know what you've got load-wise and voltage-wise immediately. You don't have time to dink around with panels. If you do, you can lose equipment.

5. One operator commented: A fuel gauge is needed on the generator model that has a fuel tank.

6. One operator commented: The gauges were not designed to give us some of the information we need. They were not precise enough. We could not tell how much current we were drawing on a particular phase. Thus, we did not know how much a particular shelter was drawing. Also, we could not see how much load we were pulling at any one time. There is nothing to show total amperage or power. We need to know if we are pulling 90 percent of the rated load of the generator, or if we are just tickling the damn thing.

7. One operator commented: The labeling was too small and the nomenclature was not military standard.

d. Controls

1. Four operators commented: The main circuit breaker needs to be accessible without having to take the side panel off.

2. One operator commented: The labeling is inadequate and does not conform to military standard.

3. One operator commented: The flimsy plastic controls, like the starter switch, are not rugged enough and will not last long with military operators.

4. One operator commented: The control box vibrates too much; it needs to be mounted more sturdily.

5. One operator commented: We could not find the governor control so that we could adjust the frequency; some of our equipment requires precisely 60 cycles.

e. Power Connections

1. One operator commented: We do not need a trailer-mounted switch box. We have our own box for the particular type of communications equipment we use (i.e., a tropo van-112). But some other applications might need a switch box on the trailer.

2. One operator commented: We had a long-run generator (with the capability of using an auxiliary fuel supply) and a short-run generator (with just its own internal fuel tank). But there was a switch box on only the long run generator. We sat them side by side and ran an umbilical cable from the short-run generator to the switch box on the long-run generator. But if something happened and the long-run generator had to be pulled out for repair, there would be no switch box for operating the short-run generator. I need a switch box on both generators. But from there on, I have no complaints. The short-run gives me the capability to make jumps easily, and the long-run lets me set up when we are in a given position for several days or a week and just let it run with the auxiliary fuel supply. I think that having a short-run/long-run pair is a good idea.

f. Equipment Location

1. Two operators commented: The batteries within the housing need covers to avoid inadvertent shorting from the terminals to other generator components. If tools are dropped on the battery terminals during maintenance, a short circuit could result.

2. One operator commented: An "Oil Only" label is needed on the spout cap for the converted fuel tank on the long-run generator to avoid confusing the oil tank with a fuel tank.

3. One operator commented: There should be a better way of changing the oil rather than having to pump it out. Being able to drain it through a drain cock is much easier, especially in a tactical environment.

4. One operator commented: The oil fill should be external so oil can be added without taking a panel off.

5. Two operators commented: The fuel fill needs to be located external to the housing so you don't have the difficulty of removing panels to refuel.

6. One operator commented: There should be two generators on a trailer instead of one.

g. Workspace and Storage Space

1. Five operators commented: There is no storage compartment on the trailers for manuals, tools and spare parts.

2. One operator commented: There is no storage place on the trailers for manuals, but I prefer to keep them in the van anyway.

3. One operator commented: There is not enough storage on the trailer for fuel cans. We normally carry about six cans.

4. One operator commented: It would be nice if there was a way of mounting an empty 55-gallon drum on the trailer; there is plenty of space for it in the front. Also, we just have one, five-pound fire extinguisher per generator. We need a couple of 25-pounders.

h. Operational Procedures

1. One operator commented: Overall, the generator is easy to operator and maintain.

2. One operator commented: It is difficult to locate the generators in place because there is a switch box on just one of them. We had to place the other one beside it with its tongue turned 180° to the first one so that the umbilical cable would reach the switch box. You usually have to manhandle it a bit to get it into the right position. In muddy ground, it could become so bogged down that you could not manhandle it.

3. One operator commented: Everything tends to get a little harder with MOPP gear on.

i. Maintenance Procedures

1. One operator commented: There was a problem with the accessibility of fuses. When several of our fuses blew out, we had to call military maintenance.

2. One operator commented: There is not enough room in the housing to check the batteries while wearing MOPP gear.

3. One operator commented: There were no maintenance problems. It was the sweetest generator we ever had.

j. Operator's Manual

1.. Two operators commented: There are no PMCS tables or troubleshooting guides in the manual.

2. One operator commented: The manual was not aimed at the operator; the information was not useable at the operator level. It needs to be written using a step-by-step procedure.

k. Tools

1. One operator commented: No tools were issued with the generator. We needed a crescent wrench for connecting the power cables.

2. One operator commented: No tools were issued. The tools we have for our vehicles are English standard, but the generator requires metric-sized tools for things like purging the fuel lines.

1. Trailer

1. One operator commented: The emergency air line to the trailers is a good idea. I feel better as a driver, a user, and a supervisor now, knowing that my troops are protected.

2. One operator commented: The trailer floor needs a non-slip surface so that you don't slip and fall when oil and fuel get on the floor.

3. One operator commented: For the long-run generator, having large fuel tanks set above the wheels of the trailer (like on the current PU628 5 KW generators) would be more convenient than having a 55-gallon drum you have to haul around.

4. One operator commented: This tropo communications unit only has 5/4 ton trucks. They cannot pull this generator and trailer. I had to make special arrangements to have a 2 1/2-ton truck pull it out to the field.

5. Two operators commented: We need a fuel gauge on the short-run generator.

Additional Comments.

1. One operator commented: One thing I particularly like about the generator is that I don't have to worry about it going down half the time. It went down once for about three hours when water got in the fuel and, in that period of time, I burned up three 10 KW gasoline generators.

2. One operator commented: After spending 16 years in the Army as a maintenance man, it was beautiful to just come out and check the oil and that was it. I really enjoyed it. I think these are damn good. The biggest problem we have in the Army today is we do not have a good quality generator that can give us what we need.

6.1.3.11.3 Ratings Made By Three Drivers

Ratings were generally "Adequate." Only two "Inadequate" ratings were given: one to the hook-up mechanism and one to design features for mounting the trailer safely.

6.1.3.11.4 Comments Made By Three Drivers

a. One driver commented: It is somewhat hard to hook up the emergency air line to the old deuce-and-a-half truck, which may be as much of a problem with the truck as with the trailer.

b. One driver commented: The hook-up mechanism with the auxiliary front wheel makes these trailers easier to hook up than the old PU 619 trailers. Two people can hook it up.

c. I towed this trailer 450 miles and have no complaints.

6.1.3.11.5 Analysis

Analysis of the preceding results led to the identification of human factors problems and the classification of these problems into the following critical and non-critical categories:

a. Critical Problems

1. Problem: A side panel must be removed in order to gain access to the main circuit breaker and the fuel fill. A different panel must be removed to see the oil pressure gauge. These cumbersome and time-consuming actions compromise the noise-reduction function of the acoustical housing.

Violations of MIL-STD-1472C: Sections 5.9.4.5 and 5.2.1.4.2

Recommendation: The circuit breaker and fuel fill should be moved to the outside of the acoustical housing. The oil pressure gauge should be located with the other gauges.

2. Problem: The absence of a fuel gauge makes it difficult to estimate fuel level, especially across shift changes.

Violation of MIL-STD-1472C: Section 5.2.1

Recommendation: Install a fuel gauge on the operator's panel.

3. Problem: On the long-run generator, the oil fill looks like the fuel fill on many other generators. This resemblance increases the likelihood of an operator's inadvertently putting fuel in the oil fill, or vice-versa.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: Redesign the oil fill so that one cannot insert a fuel nozzle into it.

4. Problem: The fact that only one generator of a pair has a switch box creates a situation where the second generator of the pair becomes useless if the generator with the switch box has to be removed for maintenance or some other purpose.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: Install a switch box on each generator/trailer.

5. Problem: The tools required for maintaining the generator are metric whereas most tools in the Army inventory are sized in the English system of measurement.

Recommendation: Issue metric tools for maintenance of the generator.

6. Problem: It is difficult or impossible to read the gauges at night because there are no panel lights and the glass window in the panel reflects the light of a flashlight. Moreover, the glass window sometimes fogs up at night.

Violations of MIL-STD-1472C: Sections 5.1.1.5 and 5.2.1.2.1

Recommendation: Consolidate all gauges, indicator lights, and controls onto a single control panel on the outside of the acoustical housing. Use external white lights on the operator's panel and low luminance, integral red lights for all gauges. The brightness of all lights should be adjustable and all lights should be extinguishable with on-off switches. This light configuration would allow maximum flexibility for operating during daytime, nighttime, and blackout conditions.

b. Non-critical Problems

1. Problem: The controls located on the outside of the acoustical housing are not labeled.

Violation of MIL-STD-1472C: Section 5.5.1

Recommendation: Label each control with respect to its function.

2. Problem: There is no storage location on the trailer for storing manuals, spare parts, and tools.

Violation of MIL-STD-1472C: Section 5.7.1.3.4

Recommendation: Provide storage space for manuals, spare parts, tools, fire extinguishers, grounding rods, and other maintenance items.

3. Problem: The generator does not have a percent load indicator.

Recommendation: A percent load gauge should be added to the operator's panel.

6.1.3.12 Manufacturer E, 10 kW, 60 Hz Generator

6.1.3.12.1 Ratings Made By Four Operators

a. Environment. Although operators generally gave "Acceptable" ratings to noise, vibration, temperature and light levels near the generator, one operator indicated that noise levels during normal operations were somewhat too low, while another operator indicated that with the baffles open during maintenance the noise level was somewhat too high. One operator indicated that the light level near the operator's panel at night was somewhat too high and another operator indicated that it was somewhat too low.

b. Indicator Lights. Operators generally gave "Adequate" and "Very Adequate" ratings to the indicator lights.

c. Gauges. Operators generally gave "Adequate" and "Very Adequate" ratings to the gauges.

d. Controls. Operators generally gave "Adequate" and "Very Adequate" ratings to controls although one operator gave an "Inadequate" rating to the labels for the controls.

e. Power Connections. Three of the operators gave "Adequate" and "Very Adequate" ratings to power connections, while one operator gave an "Inadequate" rating to the spacing between ports and "Very Inadequate" ratings to accessibility and ease of connecting cables.

f. Equipment Location. Although most ratings given to the location of various components were "Adequate," "Very Adequate" or "Not Applicable," the location of the fuel fill received three "Inadequate" ratings, and the location of gauges, location of the coolant fill, and the configuration on the trailer each received one "Inadequate" rating.

g. Workspace and Storage Space. The ratings given to workspace and storage space were somewhat variable. Two "Inadequate" ratings were given to storage space for tools and spare parts, and one "Inadequate" rating was given to each of the following: storage space for manuals; workspace for operating and maintaining the generator; and platforms, walking spaces, footholds and handholds for mounting the generator/trailer.

h. Operational Procedures. Operators generally indicated that the generator was "Easy" or "Very Easy" to operate. They also indicated that they did not operate the generator while wearing MOPP gear.

i. Maintenance Procedures. Operators generally indicated that maintenance procedures were "Easy," "Very Easy," or were not performed. One operator gave a "Very Difficult" rating to checking the load wire attachment and an "Inadequate" rating to refueling the generator.

j. Manual. Two operators indicated that they had a manual with their generator and two indicated that they did not. The two who had a manual said they used it from one to five times, and they generally gave it "Adequate" and "Easy to Understand" ratings.

k. Tools. Operators generally gave "Adequate," "Very Adequate" or "Don't Know" ratings to tools.

l. Trailer. Operators generally gave "Adequate" and "Very Adequate" ratings to the trailer.

6.1.3.12.2 Comments Made By Four Operators

a. Environment

1. One operator commented: The noise level really is not too low (even though I indicated this on the questionnaire), but if the generator shuts down, unless someone is paying attention to it, you will not know that it is off.

2. Two operators commented: The lights on the generator stay lit while the generator is running and this is a problem for tactical light discipline. A switch is needed so they can be turned on and off.

3. One operator commented: A directional panel light would be helpful.

b.. Indicator Lights. One operator commented: The main problem with the lights is that you can't shut them off to maintain blackout conditions. I taped a piece of cardboard over the panel in the field during blackout conditions.

c. Gauges

1. One operator commented: The AC ammeter never worked.

2. One operator commented: I would have liked to have had a load indicator; it helps in troubleshooting the equipment.

d. Controls

1. One operator commented: It took us awhile to find the circuit breaker switch, but we eventually found it.

2. One operator commented: All controls are in one location for good access.

e. Power Connections

1. One operator commented: It was hard to get the wrench in to turn the lug nuts. The load terminals are recessed in there and you have very little room to work with. It should take ten minutes to put on cables or take them off, but it took close to 30 or 45 minutes.

2. One operator commented: The cover over the load terminals was inadequate.

3. One operator commented: The generator cover has a tendency to hit the cover for the load terminals when it is being lowered following maintenance procedures. It could possibly break the terminal cover and come into contact with live load terminals. A stronger terminal cover or box is needed to protect the load terminals.

f. Equipment Location

1. Three operators commented: It is somewhat difficult to get the spout from a five-gallon can into the fuel tank, especially at night. Fuel tends to get spilled when refueling.

2. One operator commented: A neck extending the fuel fill outwards would be helpful.

3. One operator commented: Refueling problems can be eliminated by adding a fuel selector switch so that an auxiliary fuel supply, such as a tank on the trailer, can be used.

4. One operator commented: In order to get to the coolant fill, you have to completely raise the cover off of the generator. Bringing the radiator neck up so that it could be refilled from the outside would help.

5. One operator commented: The hinges on the cover of the generator were far too small. In order to take the pins out we had to use a pair of pliers, and to get them back in required a wrench and hammer. They were very difficult to get off.

g. Workspace and Storage Space

1. Two operators commented: There is no storage compartment on the trailer for tools, spare parts, or manuals.

2. Two operators commented: The trailer needs storage locations for more five-gallon fuel cans.

h. Operational Procedures. One operator commented: It was very easy to start the generator. All you have to do is throw a switch and it will keep cranking until it starts. The main concern is that you have to be very careful not to burn up the starter since it stays on until you shut it off again.

i. Maintenance Procedures

1. One operator commented: The batteries are in an inaccessible area and require a lot of time to replace.

2. One operator commented: It is awkward to refuel, so you tend to spill fuel.

3. One operator commented: We really didn't have any problems with the generators. They ran great, although an insulation panel started to fall down on one.

4. One operator commented: The control panel should be easily accessible for field maintenance. Also, a finer filter screen is needed on the fuel filter because we got some dirt in our fuel and had to bleed the fuel lines.

5. One operator commented: You have to shut down the engine and raise the generator cover to check the oil. We need to be able to check the oil while the engine is running.

j. Operator's Manual

1. One operator commented: Diagrams need to be printed better. Some of them did not turn out too well.

2. One operator commented: The manual did not identify the meter that was located directly beneath the hours meter. I was unsure of its function.

k. Tools. One operator commented: No tools came with the generator.

1. Trailer

1. One operator commented: The hook-up mechanism was very nice because you could easily raise or lower it and just back up the truck, rather than getting three or four people to lift the whole trailer while you hooked it up.

2. One operator commented: The power box itself is pretty good, but there is no switch box on the trailer to use in a two-generator operation.

m. Additional Comments. One operator commented: This generator seems to be a lot more efficient than the other generators I have worked with because you can run them for hours and hours. However, with some of the others you can check the oil while the engine is running. The noise level on this generator is excellent compared with the military standard 10 Kws.

6.1.3.12.3 Ratings Made By Two Drivers

The drivers gave "Easy" and "Very Easy" ratings to towing the generator/trailers, and they gave "Adequate" and "Very Adequate" ratings to trailer characteristics.

6.1.3.12.4 Comments Made By Two Drivers

One driver commented: It seemed like the load on the trailer was a bit heavier with these generators compared to the old 10 Kws, but I had no problems. Also, the handcrank is a big improvement.

6.1.3.12.5 Analysis

Analysis of the preceding results led to the identification of human factors problems and the classification of these problems into the following critical and non-critical categories:

a. Critical Problems

1. Problem: The lugs are too close together, making it difficult to hook up more than one cable.

Violation of MIL-STD-1472C: Section 4.4(d)

Recommendation: Space the lugs farther apart on the generator.

2. Problem: The fuel fill is inside the acoustical housing, so refueling the generator is difficult.

Violation of MIL-STD-1472C: Section 4.4(d)

Recommendation: Extend the neck of the fuel fill spout so that it sticks out from under the housing.

3. Problem: Performing preventive maintenance on the generator requires raising the whole housing which covers the generator. This is time consuming and awkward, particularly if there is anything overhead such as tree branches or trailer canvas supports. Also, there is no means of securing the housing in the upright position when performing maintenance.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: Design and install several access doors on the housing to allow easier access to the generator. Install a positive lock system to secure the housing when it is opened.

b. Non-critical Problems

1. Problem: Lights on the operator's panel are too bright for tactical light discipline at night. In the field, operators taped pieces of cardboard over the panel at night to maintain light discipline.

Violation of MIL-STD-1472C: Section 5.2.1.2.1

Recommendation: Use external white lights on the operator's panel and low luminance, integral red lights for all gauges. The brightness of all lights should be adjustable and all lights should be extinguishable with on-off switches. This light configuration would allow maximum flexibility for operating during daytime, nighttime, and blackout conditions.

2. Problem: There is no storage location on the trailer for securing manuals, spare parts, and tools.

Violation of MIL-STD-1472C: Section 5.7.1.3.4

Recommendation: Storage space should be provided for manuals, tools, spare parts, fire extinguishers, grounding rods, and other maintenance items.

3. Problem: Additional five-gallon fuel cans are needed to have an adequate reserve of fuel in case the fuel truck is detained.

Recommendation: Increase the storage space for fuel cans on the trailer--at least two additional fuel cans are needed.

4. Problem: There is no switch box on the trailer which allows for the rapid switching of power production from one generator to another without a loss of power to the distribution system.

Recommendation: Install a switch box on each generator trailer.

5. Problem: There is no percent load indicator on this generator. One is needed.

Recommendation: A percent load gauge should be added to the operator's panel. The gauge should indicate what percent of rated load is being placed on the generator.

6.1.3.13 Manufacturer A, 15 kW, 60 Hz Generator, Modified

6.1.3.13.1 Ratings Made By Three Operators

a. Environment. Two operators gave "Somewhat too high" ratings for the noise levels of the generator when the baffles and doors were closed and when they were open. Two operators gave "Acceptable" ratings for the vibration level and all three operators gave "Acceptable" ratings for the temperature level near the generator during normal operations. The three operators gave "About right" ratings for the daytime and nighttime light levels at the operator's panel during normal conditions. Two operators gave "Somewhat too low" ratings for the nighttime light levels at the operator's panel during blackout conditions.

b. Indicator Lights. In general, the operators gave "Adequate" and "Very Adequate" ratings for the indicator lights.

c. Gauges. In general, the operators gave "Adequate" ratings for the gauges. However, one operator gave an "Inadequate" rating for the location of the gauges.

d. Controls. In general, the operators gave "Adequate" and "Very Adequate" ratings for the controls.

e. Power Connections. The three operators gave "Adequate" ratings for the labeling of lugs, size of lugs, and spacing between lugs. One operator gave "Inadequate" ratings for the accessibility of power connections and ease of connecting cables.

f. Equipment Location. In general, the operators gave "Adequate" ratings for the location of panels, indicator lights, gauges, control, and other items of equipment.

g. Workspace and Storage Space. The three operators gave "Adequate" ratings for the amount of workspace within the acoustical enclosure and the amount of workspace outside the acoustical enclosure. Two operators gave "Adequate" ratings for the amount of storage space provided for fuel cans and manuals. The ratings for the other items relating to storage space were quite variable.

h. Operational Procedures. Three operators gave "Easy" and "Very Easy" ratings for locating the generator in place, stopping the generator normally, and operating the generator while performing other duties. Ratings for other items were quite variable—with several "Did Not Perform" responses.

i. Maintenance Procedures. Three operators gave "Easy" and "Very Easy" ratings for checking the ground terminal connection and checking instruments for normal operation. Two operators gave "Easy" and "Very Easy" ratings for checking batteries, checking engine oil, checking for fuel leaks, and refueling the generator. One operator gave "Difficult" ratings for performing overall check of generator system and servicing the batteries.

j. Operator's Manual. Two operators stated that no manuals were provided, so meaningful ratings were not obtained for the manual.

k. Tools. The ratings given for the adequacy of normally-issued tools were quite variable, so meaningful summaries of ratings could not be made.

1. Trailer. The operators were generally satisfied with the trailer--giving two or three "Adequate" ratings for every item. One operator was dissatisfied with the protective cover over the lugs; he rated it "Very Inadequate". The same operator was also dissatisfied with the design features for mounting the trailer safely; he rated it "Inadequate."

6.1.3.13.2 Comments Made By Three Operators

a. Environment

1. One operator commented: The gauges are hard to see with a red lens flashlight. The dials should be covered with a special coating that would reflect red light.

2. One operator commented: The lighting configuration is acceptable for the gauges, but there is no light for checking oil.

3. One operator commented: There is not enough visibility with the red lens itself. Perhaps with a luminous dial, a red lens would be effective. But, just black letters on a white background are not sufficient.

4. One operator commented: A light is needed under the access panel so you can see to check oil at night. Without a flashlight, you can't even find the dipstick in there.

5. One operator commented: The noise level was too high tactically. In a tactical situation, they could be heard 1/4 to 1/2 mile away, and that would not be acceptable. Also, it is still necessary to wear ear protection.

6. One operator commented: The noise levels with baffles and doors open are somewhat too high. Having to check the oil while listening to the motor and generator--it's just too loud. There's not a lot you can do about it with the doors open, however.

b. Indicator Lights. No comments.

c. Gauges. One operator commented: The generator burned a lot of oil, but the gauges indicated this was normal. The oil gauge didn't show it was low on oil even though a check of the dipstick every day would show it was low on oil. It would need a quart a day.

d. Controls. No comments.

e. Power Connections

1. One operator commented: The accessibility to the power connections was inadequate. The plastic panel mounted with 6 3/8" bolts restricts access to the lugs. You can't get your hands behind it, so you have to take the panel off to get to the lugs. It would be better if there were some way to mount that panel differently--say with lug nuts or some kind of quick-release device. As it is now, you can't get your hands in there with the plastic panel attached.

2. One operator commented: A lug wrench was issued with the generator, but it was the wrong size.

f. Equipment Location

1. One operator commented: The Emergency Stop-Run switch is inadequately located. The little circuit breaker button is located right under the test lights--it's hard to see and it's not labeled. If you've got to shut the generator down in a hurry, you'd never be able to find it--since it's very small, unmarked, and hard to pull out.

2. One operator commented: The oil fill is located in such a position within the housing that you need a funnel to add oil.

g. Workspace and Storage Space

1. One operator commented: The storage space for fuel cans is inadequate. There is only space for 10 gallons of extra fuel. That's about 10 to 14 hours worth of fuel. If you're going to be out there for 6 days (or longer), you've got to get fuel from some other source. Ten more gallons of fuel would not be hard to mount on that generator.

2. One operator commented: The storage space for tools is inadequate. There's one little box on the generator and you can get only a few things in it--such as brass ground rods and a few little accessories. There's no space to store long ground rods, manuals, etc. on the generator. In addition, you can't lock the accessories box to prevent pilferage. If you can't lock it, you really can't use it.

h. Operational Procedures

1. One operator commented: The access door latches are very poor. You can spend 5 minutes getting one panel open, because the latches keep screwing out until they finally release. It's also hard to close the access doors and it's almost impossible to tell if both latches are latched. Suggestion: The access doors should have flip-type latches. If we do use the other type of latch, you should design it so it takes a half turn to open and a half turn to close--instead of 8 or 10 turns to get it to do anything.

2. One operator commented: When you try to close the access doors, there's no way to tell how well they're latched. You can't feel any type of positive locking action on the doors. If you had just a small portion of the access panel latched, you wouldn't know it until the door came open unexpectedly.

i. Maintenance Procedures

1. One operator commented: The actual performance of PMCS wasn't too difficult, except for servicing the batteries. The batteries are in front behind an access panel underneath that cowling and there's no space to get in to work on them. You have to just about crawl into the battery compartment to get to the water.

2. One operator commented: Checking the radiator is easy if you know where the radiator cap is. It's under a small panel on top of the generator itself. I had to look around a bit to find out how to get to the radiator cap.

3. One operator commented: The generator started using too much oil in the field. It was leaking oil out the oil drain plug, so we shut it down for several days and waited for maintenance on it.

j. Operator's Manual. One operator commented: No manual was issued with the generator. We needed one, so we'd know how long to run it before shutting it down for PMCS, know the proper operating procedures, etc.

k. Tools. One operator commented: The lug wrench for the terminal lugs was the wrong size.

1. Trailer

1. One operator commented: The design features for mounting the trailer safely are inadequate. Getting up on the trailer is hard because you have to mount it from the back. In the back, the operator's panel doors are latched out and are in your way when you try to get up on the fender. You have to close a panel door in order to get around it. Also, there are no handholds on the acoustical box to help you get up. Some handholds are needed on the side corners at the top--you could grab them as you mounted the fender skirting.

2. One operator commented: A handle on the exhaust hood would be very helpful for opening the hood. The hood is hard to open by yourself and the addition of a handle would make it a one-man operation.

6.1.3.13.3 Ratings Made By One Driver

a. The driver gave "Easy" and "Very Easy" ratings for all items relating to towability and the ability to back up with the generator/trailer attached.

b. The driver gave "Adequate" ratings to all items relating to the design features of the trailer.

6.1.3.13.4 Comments Made By One Driver

The driver commented: I had no problems towing the generator, except that I could not see it in my rear view mirrors.

6.1.3.13.5 Analysis

Analysis of the preceding results led to the identification of human factors problems and the classification of these problems into the following critical and non-critical categories:

a. Critical Problems

1. Problem: The noise levels with access doors closed and with them open are too high for tactical operations--i.e., dB(A) at one foot from the opened, control panel door is 91.

Violation of MIL-STD-1472C: Section 5.8.3.1

Recommendation: Before further consideration is given to this generator, the Army should retrofit it with a better acoustical package.

2. Problem: The power connections compartment is too cramped. The plastic safety guard mounted with 6 3/8" bolts restricts access to the lugs. You can't get your hands behind it, so you have to take the panel off to get to the lugs.

Violations of MIL-STD-1472C: Sections 4.4(f) and 5.9.4.5

Recommendation: Either enlarge the power connections compartment by making it wider and deeper or mount the plastic safety guard with some type of quick-release device (so it is easy to take the guard off and put it back on).

3. Problem: The Emergency Stop-Run control is the wrong type of control, it is not adequately located, and it is not labeled. The control is a circuit breaker button, located right under the test lights. It is small, unmarked, difficult to see, and hard to pull out. An operator would have a difficult time trying to shut the generator down in an emergency.

Violation of MIL-STD-1472C: Section 5.9.17.2.4

Recommendation: The Emergency Stop-Run control should be either a toggle bat or legend switch. It should be located in a prominent position on the operator's control panel and be labeled appropriately.

4. Problem: The access doors are too difficult to open and close for normal maintenance and emergency purposes. The multiple-turn latches are slow to operate and unreliable as a means of closure. There is no way to tell how well the doors are latched, since the operator can feel no positive locking action. In addition, the fold-up design and gravity-latch mechanism for keeping the doors in the "opened" position are safety hazards (i.e., opened doors could be accidentally bumped and could fall on the operator or other personnel in the area).

Violations of MIL-STD-1472C: Sections 4.4(m), 5.9.9.2, 5.9.9.4.1(b), 5.9.10.2, and 5.9.12.9

Recommendation: The access doors should be self-supporting so they can be opened quickly and easily. They should be hinged on one side and latched on the other (with tongue-and-slot catches). This configuration would allow the doors to be opened to the sides of the generator. The doors should have positive locks or braces to secure them when they are open. [Presently the door panels have hinges on top and multiple-turn catches on bottom. When they are in the "opened" position, they are folded and latched to the top of the generator.]

b. Non-critical Problems

1. Problem: The gauges have no integral lights. The red lens does not provide enough light to make the gauges readily visible at night.

Violations of MIL-STD-1472C: Sections 4.4(h), 5.1.1.5, and 5.2.1.2.1.1

Recommendation: Use 3 or 4 external white lights on the operator's panel and low luminance, integral red lights for all gauges. The brightness of all lights should be adjustable and all lights should be extinguishable with on-off switches. This light configuration would allow maximum flexibility for operating during daytime, nighttime, and blackout conditions.

2. Problem: There is an inadequate amount of storage space on the generator/trailer. The small accessories box can get only a few things in it. In addition, the operator can't lock the box to prevent pilferage.

Violations of MIL-STD-1472C: Sections 4.4(d) and 5.9.1.2

Recommendation: Increase the storage space to accommodate more fuel cans, fuel filters, oil cans, oil filters, special tools, long grounding rods, and an operator's manual.

3. Problem: The batteries are difficult to access for maintenance purposes. They are in front behind an access panel, but there is no space to get in to work on them.

Violations of MIL-STD-1472C: Sections 4.4(f) and 5.9.4.5

Recommendation: The batteries should be mounted side-by-side on a sliding rail, behind the access panel. The rail should allow the batteries to slide in and out easily so they can be accessed individually without difficulty.

4. Problem: The design features for mounting the fender skirts of the trailer are inadequate. The operator has to mount the trailer from the back. In the back, the operator's panel doors are normally braced out and are in the way when the operator tries to get up on the fender. He has to close the panel door in order to get around it. Also, there are no handholds on the acoustical box to help the operator mount the trailer.

Violations of MIL-STD-1472C: Sections 4.4(f) and 4.4(i)

Recommendation: The generator/trailer should be redesigned so that steps and handholds are positioned to facilitate the operator's mounting of the fender skirts.

5. Problem: The exhaust hood is hard to open by one soldier alone.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: Add a handle to the middle of the exhaust hood so it can be opened by one soldier.

6.1.3.14 Manufacturer B, 15 kW, 60 Hz Generator

6.1.3.14.1 Ratings Made by Four Operators

a. Environment. The four operators gave "Acceptable" ratings for the noise levels of the generator when the baffles and doors were closed. Two operators gave "Somewhat too high" ratings for the noise levels when the baffles and doors were open. The four operators gave "Acceptable" ratings for the vibration level and temperature level near the generator during normal operations. The four operators gave "About right" ratings for the daytime light levels at the operator's panel during normal operation, but three operators gave "Somewhat too high" and "Much too high" ratings for the nighttime light levels at the panel during normal operation. The four operators gave "About right" ratings for the nighttime light levels at the operator's panel during blackout conditions.

b. Indicator Lights. In general, the operators were satisfied with the indicator lights. Three operators gave "Adequate" and "Very Adequate" ratings for the following items: Brightness during daylight, Brightness at night, Location of indicators, Labels, and Amount of information given by indicator lights.

c. Gauges. The four operators gave "Adequate" and "Very Adequate" ratings for the brightness of gauges during daylight and the brightness of gauges at night. Two operators gave "Inadequate" and "Very Inadequate" ratings for the location of the gauges.

d. Controls. The four operators gave "Adequate" and "Very Adequate" ratings for the type of control, size, shape, spacing between controls, and resistance. Three operators gave "Adequate" and "Very Adequate" ratings for the labels. Two operators gave "Inadequate" and "Very Inadequate" ratings for the accessibility of the controls.

e. Power Connections. There was a great deal of variability among the ratings for every item relating to power connections. However, three operators gave "Adequate" and "Very Adequate" ratings for the size of lugs.

f. Equipment Location. There was a great deal of variability among the ratings for almost every item relating to equipment location. For instance, two operators gave a "Very Inadequate" rating for the location of the operator's control panel and the other two operators gave "Adequate" and "Very Adequate" ratings for the same item. Three operators gave "Adequate" and "Very Adequate" ratings for the configuration on trailer.

g. Workspace and Storage Space. There was a great deal of variability among the ratings for every item in this section. However, three operators gave "Inadequate" and "Very Inadequate" ratings for the amount of storage space provided for fuel cans and the amount of storage space provided for grounding rods.

h. Operational Procedures. In general, the operators were satisfied with the difficulty level for most of the operational procedures. There were two items which did not receive a preponderance of "Easy" and "Very Easy" ratings. They were "Starting up generator manually" and "Switching power from one generator to the other in a pair of generators." [These two items were not applicable for this generator, since it cannot be started manually and it was not used in a paired configuration.]

i. Maintenance Procedures. The four operators gave "Easy" and "Very Easy" ratings for the following items: Perform overall check of generator system, Check load wire attachment, Check ground terminal, Check instruments for normal operation, and Check for fuel leaks. Most of the other items had a preponderance of "Did Not Perform" and "Not Applicable" ratings.

j. Operator's Manual. An operator's manual was not present with this generator, so ratings for the manual were not obtained.

k. Tools. Few ratings were made in this section, so summaries are not appropriate.

l. Trailer. In general the operators were satisfied with the trailer. Three or four operators gave "Adequate" and "Very Adequate" ratings for every item except "Protective cover over lugs" (which received one "Inadequate" rating) and "Fuel storage" (which received two "Very Inadequate" and one "Inadequate" ratings).

6.1.3.14.2 Comments Made By Four Operators

a. Environment

1. One operator commented: The lights on the operator's panel are too bright. The panel should have a sliding cover to cover the lights after maintenance is done.

2. One operator commented: Put blackout lights on the operator's panel.

3. One operator commented: There is a bright green light that stays on constantly at the back of the generator. At night, you can tell where the generator is located because of this light. There should be a way to dim this light, or turn it off altogether.

b. Indicator Lights

1. One operator commented: The bright green light at the back of the generator stays on constantly. At night, you can tell where the generator is located because of the light. There should be a way to dim it or turn it off.

2. One operator commented: Indicator lights should be at eye level--approximately.

c. Gauges

1. One operator commented: Gauges and their labels should be at eye level--approximately.

2. One operator commented: The fuel gauge seemed to be off--all other gauges were very good.

3. One operator commented: Gauges are located down near the bottom of the generator. You have to lean over or bend down to see them. It is inconvenient, and at night it is difficult because of all the camouflage, etc. To solve this problem, gauges should be placed at eye level.

d. Controls

1. One operator commented: The controls are good, but they should be located at shoulder-height level or at a location more easily accessible.

2. One operator commented: You had to squat down to read some of the labels and to start the generator.

e. Power Connections

1. One operator commented: The labeling for the lugs should be standardized and put on a plate next to the hock. Before we got the hocks built, we just stuck the wires in the holes. But, if we used the same sequence as with the mil std generators, we would have reversed the polarity.

2. One operator commented: The lugs need to be placed in a position where they are more accessible. They are in a bad place now. Also, the lugs and labels should be larger. There should be more space between lugs.

f. Equipment Location

1. One operator commented: The operator's control panel, with its associated indicator lights, gauges, and switches, is too low—it should be moved up to eye level.

2. Two operators commented: The fuel fill should be at a trailer-level location (and away from the batteries). This would allow the operator to rest heavy fuel cans on trailer parts while filling the generator with fuel. The present location of the fuel fill is too high and is right above the batteries. This configuration is a potential safety hazard, so the fuel fill should be relocated.

3. One operator commented: To gain access to most items of equipment, you would need to take off a panel by using a screwdriver. A quicker release mechanism would make it a lot easier to get inside to fix something.

4. One operator commented: When you overfill the radiator, water drains out of the overfill tube into the trailer. Since there are no drainage holes, rust and erosion will result.

5. One operator commented: You need to find a location for an additional fuel tank to be used for hot loading of fuel.

g. Workspace and Storage Space

1. One operator commented: The trailer has enough space for storing fuel cans, tools, spare parts, manuals, and grounding rods--but brackets, tool boxes, etc. have not been built.

2. One operator commented: There isn't any storage space really. You need storage space for fuel cans containing reserve fuel--to be used if the fuel tanker doesn't make it. Also, you need space for storing tools such as pioneer tools. The only spare parts you need to store are light bulbs. I would prefer to keep a manual inside the generator. We had no place for grounding rods, so we stuck them in the van.

3. One operator commented: The fenders are too narrow and unsafe for you to climb up on to work on the generator. If they were wet and you slipped, you could get hurt.

4. One operator commented: There was no space to store fuel cans if you brought all the spare parts along that the company recommends you bring. We should carry 4 fuel cans with us as reserve. We didn't do any fueling or refueling with cans during the exercise; however, it would be difficult to do so because the fuel fill is set fairly high.

h. Operational Procedures

1. One operator commented: It was very difficult to connect the power cable to the generator. The lugs need to be placed in a position where they are more accessible.

2. One operator commented: Generally, it would be easy to operate the generator while performing other duties. However, the fuel gauge on one generator was not accurate and we had to check the generator more often than we would have if we had had a reliable gauge.

i. Maintenance Procedures

1. One operator commented: It is very difficult to perform an overall check on the generator system because the top door is hard to open.

2. One operator commented: It is very difficult to check engine oil because you have to first open the heavy top door.

3. One operator commented: It is very difficult to refuel the generator due to the high location of the fuel fill.

4. One operator commented: It is difficult to change the oil. The oil pump-out system should be replaced with an electric pump system. The time spent on changing the oil on the generators could mean the difference between completing the mission promptly or spending the same time changing the oil.

5. One operator commented: Checking engine oil involved getting up on the generator, lifting the upper hood, and reaching down in. It would be easier if the dipstick were more to the side where you could just open a panel to check engine oil.

6. One operator commented: I didn't like changing the oil every 100 hours, i.e., every 4 days. It's a hassle to have to tear down the generator and bring it back up every 4 days.

7. One operator commented: We need clarification as to whether oil changes are needed every 48 or every 100 hours.

j. Operator's Manual. An operator's manual was not present with the generator, so comments were not obtained.

k. Tools. No comments were made about the adequacy of normally-issued tools.

1. Trailer

1. One operator commented: The trailer needs a bigger, all-terrain type of tire. The present tires are regular road-size tires.

2. One operator commented: The protective cover over the terminal block was secured by wing nuts. It took awhile to unfasten and refasten them; consequently, a lot of time people would not fasten them back in place.

3. One operator commented: The fuel tank needs more capacity so it can provide fuel for more than a 24-hour period.

4. One operator commented: The power or terminal box should be more water tight. It is adequate for dry conditions but for rainy conditions, mud could splash up in it.

5. One operator commented: There should be a better method for mounting the trailer. When you have to climb up on the fenders to work on the generator, the walkspace is too narrow and unsafe. If the fenders were wet and you slipped, you could get hurt.

6. One operator commented: There was no space for storing fuel cans if you brought all the spare parts along that the company recommends that you bring.

7. One operator commented: The trailer was well balanced and could be moved with minimum manpower (with its third wheel up front). The trailer is very roomy and could carry extra equipment. The brake was located in a good position.

6.1.3.14.3 Ratings Made by One Driver

a. The driver gave "Very Easy" ratings for all towability items, except for towability over gravel roads at speeds exceeding 25 mph--which he rated as "Not Applicable."

b. The driver gave "Adequate" and "Very Adequate" ratings for all items relating to the design features of the trailer, except "Tire size"--which he rated as "Neither Adequate Nor Inadequate."

6.1.3.14.4 Comments Made by One Driver

- a. The driver commented: The trailer needs all-terrain tires.
- b. The driver commented: In order to back up, one must get out of the truck and lift up/turn a knob on the trailer. If you are by yourself, this requirement is too time consuming. If you want to pull forward, you have to get out of the truck and turn the knob again.

6.1.3.14.5 Analysis

Analysis of the preceding results led to the identification of human factors problems and the classification of these problems into the following critical and non-critical categories:

a. Critical Problems

1. Problem: The labeling for the load terminals is different from the labeling scheme used for U.S. military generators. Also, the labels are too small for adequate visibility.

Violation of MIL-STD-1472C: Section 5.5.1.1

Recommendation: Make the label for a designated terminal on the generator consistent with the label for the corresponding terminal on a U.S. military standard generator. Make the labels larger.

2. Problem: The power connections compartment is too cramped. The lugs are too small and are placed too close together. It is difficult to connect 3 or 4 large power cables to the lugs--as the Army must do sometimes.

Violations of MIL-STD-1472C: Sections 4.4(f) and 5.9.4.5

Recommendation: Enlarge the power connections compartment, enlarge the lugs, and spread the lugs apart more. Consideration should be given to relocating the power connections compartment to a more accessible area on the generator.

3. Problem: The fuel fill is located too high on the generator. It is very difficult for the operator to lift fuel cans up to the fuel fill. Also, the fuel fill is located right above the batteries. The location constitutes a potential safety hazard.

Violations of MIL-STD-1472C: Sections 4.4(c), 4.4(f), and 4.4(m)

Recommendation: The fuel fill should be at a trailer-level location (away from the batteries). An ideal location would be in the front of the generator near the trailer tongue area. This would allow the operator to rest heavy fuel cans on the trailer while he performs steps in the refueling process.

4. Problem: Most items of equipment on this generator are not very accessible. In most cases, you must use a screwdriver to take a panel off before you can get to the equipment.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: A quicker release mechanism on all the panels would make it easier to get inside the generator for normal and emergency maintenance.

5. Problem: It is very difficult and very time consuming to change the engine oil. The oil pan is normally inaccessible and does not, therefore, have a drain plug. Instead, the oil is drawn out with a hand pump. The time spent on changing the oil could mean the difference between completing the mission promptly or spending the same time changing the oil.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: Move the oil pan to a more accessible location and add a drain plug or replace the hand-pump system with an electric pump-out system.

b. Non-Critical Problems

1. Problem: The light configuration on the operator's control panel and instrument panel is inadequate. There are no panel lights and the green "Load On" light is too bright for blackout conditions.

Violations of MIL-STD-1472C: Sections 4.4(h), 5.1.1.5, and 5.2.1.2.1.1

Recommendation: Use 3 or 4 external white lights on the operator's control panel and instrument panel. Use low luminance, integral red lights for all gauges. The brightness of all lights should be adjustable and all lights should be extinguishable with on-off switches. This light configuration would allow maximum flexibility for operating during daytime, nighttime, and blackout conditions.

2. Problem: The indicator lights, gauges, and controls are located too low on the generator. The operator must lean over or bend down to see them. This requirement is inconvenient and difficult to do at night because of the camouflage net and other obstructions around the rear of the generator.

Violation of MIL-STD-1472C: Section 4.4(f)

Recommendation: The operator's control panel and the instrument panel should be raised to eye-level of a typical operator standing on the ground.

3. Problem: There are no drainage holes for water inside the acoustical box. When an operator overfills the radiator, water drains out the overflow tube into the generator and stays there. Rust and erosion will result.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: Add a water drainage hole to the bottom of the generator so excess water will drain out or re-route the overflow tube so that water drains outside the acoustical enclosure.

4. Problem: There is an inadequate amount of storage space on the generator/trailer.

Violations of MIL-STD-1472C: Sections 4.4(d) and 5.9.1.2

Recommendation: Make use of the potential storage space already on the generator/trailer. Construct tool boxes and storage bins, and place brackets on generator/trailer surfaces--so that fuel cans, fuel filters, oil cans, oil filters, special tools, grounding rods, operator's manual, etc. may be kept near the generator at all times.

5. Problem: Walking spaces around the fender skirts on the trailer are too narrow and slippery. It is difficult for operators to balance themselves on the walkways while they perform operator maintenance.

Violations of MIL-STD-1472C: Sections 5.14.2.3 and 5.7.7.6

Recommendation: Widen the walkways around the fender skirts to at least 27 inches and treat the exterior personnel platforms with a nonskid material conforming to specification MIL-W-5044.

6. Problem: The top door is too heavy and, consequently, too hard to open, latch in the "opened" position, unlatch, and close. Having to raise and lower the door makes it difficult to check and add engine oil, to check and add water/coolant, and to perform other maintenance tasks.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: Place the dipstick more to the side of the generator and behind a panel that can be opened when the operator needs to check oil. Place the water/coolant fill on top of the generator so that the radiator may be filled externally.

7. Problem: The tires on the trailer are regular road-size tires. They are too small and are not designed for cross-country travel.

Violation of MIL-STD-1472C: Section 4.9

Recommendation: Replace the present tires with bigger, all-terrain tires.

8. Problem: If the driver wants to back up, someone must lift up/turn a knob on the trailer. If he wants to pull forward, the knob must be turned again. If the driver is by himself, this requirement is very time consuming and inconvenient. He must jump in and out of the truck to locate the generator/trailer in place.

Violation of MIL-STD-1472C: Section 4.4 (m)

Recommendation: Redesign the brake system to eliminate the nuisance of having to manually change the positions of the knob.

6.1.3.15 Manufacturer F, 15 kW, 60 Hz Generator

6.1.3.15.1 Ratings Made By Four Operators

a. Environment. In general, the operators gave "Acceptable" ratings for the noise levels of the generator when the baffles and doors were closed and when they were open. In general, the operators gave "Acceptable" ratings for the vibration level and temperature level near the generator during normal operations. In general, the operators gave "About right" ratings for the daytime light levels and nighttime light levels at the operator's panel during normal conditions. However, one operator expressed dissatisfaction with the lights on the operator's panel during nighttime, blackout conditions.

b. Indicator Lights. In general, the operators gave "Adequate" and "Very Adequate" ratings for the indicator lights.

c. Gauges. In general, the operators gave "Adequate" and "Very Adequate" ratings for the gauges.

d. Controls. In general, the operators gave "Adequate" and "Very Adequate" ratings for the controls. However, one operator was displeased that the throttle was inoperative.

e. Power Connections. The operators gave "Adequate" and "Very Adequate" ratings for most aspects of the power connections, except the size of the lugs.

f. Equipment Location. In general, the operators gave "Adequate" and "Very Adequate" ratings for the location of the operator's control panel and its accompanying lights, gauges, and switches. However, they were less satisfied with the location of equipment inside the acoustical enclosure. Three operators rated the location of the water/coolant fill as "Inadequate" and "Very Inadequate."

g. Workspace and Storage Space. In general, the operators were dissatisfied with the amount of storage space for fuel cans and grounding rods.

h. Operational Procedures. In general, the operators were satisfied with the generator's ease of operation during normal conditions.

i. Maintenance Procedures. Two operators noted that performing PMCS might be difficult on this generator. They gave "Difficult" and "Very Difficult" ratings for changing engine oil, checking radiator, and servicing radiator.

j. Operator's Manual. Three operators stated that no manuals were provided, so meaningful ratings were not obtained for the manual.

k. Tools. In general, the operators gave "Adequate" ratings for the normally-issued tools, considering their sufficiency for performing PMCS and troubleshooting.

l. Trailer. Two operators gave "Inadequate" and "Very Inadequate" ratings to "Height of chassis above ground," "Tire configuration on each side," "Tire size," "Size of lugs," and "Brakes."

6.1.3.15.2 Comments Made By Four Operators

a. Environment. One operator commented: The lights on the operator's panel do not allow light discipline in a tactical situation. The panel lights should be either placed behind a closed panel, or mounted in the open across the top and have a switch that can be turned on and off. The panel lights should not be visible during blackout conditions. The present lights are adequate in the sense that you can see the whole panel. But, as far as light discipline goes, the overall setup is inadequate.

b. Indicator Lights. One operator commented: Indicator lights need to be wider so they're easier to see at night. The brightness of the indicator lights during daytime is very adequate. You can see them anywhere, anytime during the day.

c. Gauges

1. Three operators commented: The generator has no fuel gauge to determine fuel consumption. One is needed because you might be running on empty and not know it. Out here in the field we need power at all times (24 hours a day), so we don't need to run out of fuel. A fuel gauge should be placed on the operator's panel.

2. One operator commented: The gauges give very explicit temperature, amperage, and oil pressure readings. The mil std oil pressure gauges go from 0 to 30 to 60, etc. On this generator, the oil pressure gauge goes from 5 to 10 to 20, etc. Since these are smaller increments, the operator can make more precise and accurate readings.

3. One operator commented: The gauges are at eye level, so you're looking at them at all times when you do things around the generator.

d. Control

1. One operator commented: The frequency adjustment (throttle) on this generator didn't work. The generator just operated at about 55 Hz.

2. One operator commented: The speed control should have a knob on it, so you could just turn it to change frequency. Presently you must use a wrench to loosen the speed control and then turn it with a screwdriver.

e. Power Connections

1. Two operators commented: The load lugs are not large enough for the cabling requirements of the generator. They should use lugs about the same size as those on mil std generators. I had to cut our wires down to make them small enough to fit the lugs on this generator.

2. One operator commented: On mil std equipment, lugs are labelled on a fiberglass board. Sometimes it wears out or gets dirty, and you can't read it. With a lot of cables in there, it may be hard to read. Whereas, the labeling on this generator is right across the top and is very legible.

3. Two operators commented: The power connections should be moved to the side of the acoustical box. They are presently located beneath the operator's panel in a highly trafficked area. Someone could accidentally bump up against the lugs and get shocked. Also, put a better cover over the lugs for safety reasons.

f. Equipment Location

1. Three operators commented: The water/coolant fill is hard to locate and reach. It's hard to put water in or even check it. The radiator neck should be placed on the outside of the acoustical box for easier servicing—preferably on top of the box.

2. One operator commented: The battery is in a poor location for getting it out. A panel door is needed so the battery can be slid in and out for maintenance.

g. Workspace and Storage Space

1. One operator commented: Storage space is more than sufficient for storing spare parts, tools, and manuals. I think it is an excellent idea. The mil std generators don't come close to that much storage space. The storage space on this generator is away from the engine and generator itself. If you have an oil leak, oil won't get on the parts or tools.

2. One operator commented: The storage space is too compact to keep your filters, oil, grounding rods, spare parts, etc.

h. Operational Procedures. Two operators commented: The operation of the set is very easy and simple. Pushbutton controls are a lot easier to operate than switches.

i. Maintenance Procedures

1. One operator commented: Changing oil is virtually impossible. The drain on the outside of the acoustical box sits at a higher level than the oil pan. The oil will not drain out because it can't flow uphill. There is a hose that comes off of the oil pan and an L-shaped connection, and the hose goes uphill to the drain on the side of the generator. If they took the hose straight down through the floor and then over to the side, it would work fine. We were supposed to change the oil in the field, but we couldn't.

2. One operator commented: It is easy to check and fill oil, but the dipstick needs to be redesigned so you can check the oil while the generator is running. We don't want to have to shut the generators down or changeover in order to check the oil.

3. Three operators commented: The location of the water/coolant fill makes it hard to check the water level and hard to put water into the radiator.

4. One operator commented: The dual air filter system on this generator is better than the air filter system on mil std generators.

5. One operator commented: A mil std battery would work better and would be easier to replace than the one on this generator.

j. Operator's Manual. No manuals were issued so no comments were given.

k. Tools. One operator commented: A fiberglass wrench is needed for making connections to the load terminals so you won't strip the lugs. These wrenches are provided with mil std generators.

1. Trailer

1. One operator commented: The trailer is too small for the generator and sits too low to the ground. The fuel tank is right on the bottom, so you have to worry about puncturing the fuel tank when travelling over rough terrain. If the generator were mounted a little higher, it would work a lot better and be a lot safer. Most of these problems would be solved if this generator were mounted on a mil std trailer to give the generator/trailer greater mobility and make it safer to transport.

2. Three operators commented: The trailer is not high enough off the ground for mobility in tactical situations and over rough terrains. Problems could arise when trying to locate the generator in place when on hilly terrain. Also, the trailer needs to be built heavier, with sturdier axles. The hook-up mechanism and landing legs are not sturdy enough for movement during road maneuvers. The trailer has only 1 landing leg on its side--that's not going to work. The generator should be mounted on a military standard trailer.

3. One operator commented: The brakes on the trailer locked up when we tried to back up. There was a hydraulic ram that engaged the brakes whenever you backed up the trailer. It locked the wheels up and you could not back up. We unhooked the trailer from the truck and rolled it by hand to back it into where we wanted it. It was easy enough to roll by hand, but the brakes should be redesigned so a truck can back up the trailer.

4. One operator commented: When the operator of a 2 1/2-ton truck was reversing with the trailer in the field, the wheels locked up. But, over in the motor pool, it comes back easy.

5. Two operators commented: The lights on the trailer were 12 volts instead of 24 volts like the other trailer lights used by the Army.

6. One operator commented: The trailer has cheap safety features, i.e., no air brakes and only 1 safety chain.

6.1.3.15.3 Ratings Made By Three Drivers

a. The three drivers gave "Very Easy" ratings for the towability of the generator/trailer on straight, paved and gravel roads at speeds below 25 mph and above 25 mph. The three drivers gave "Very Easy" ratings for the towability around curves on paved roads and gravel roads. Two drivers gave "Very Difficult" ratings for the ability to back up with generator/trailer attached.

b. The three drivers gave "Adequate" and "Very Adequate" ratings for the following items: Overall Size and Weight of Trailer, Length of Trailer, Sturdiness of Trailer, Tire Configuration on Each Side, Tire Size, Hook-up Mechanism, and Design Features For Mounting Trailer Safely. One driver gave "Inadequate" ratings for "Width of Trailer" and "Brakes."

6.1.3.15.4 Comments Made By Three Drivers

a. One driver commented: On dirt roads, the trailer locks wheels--sometimes both of them. The brake system also locks on muddy surfaces.

b. One driver commented: It is impossible to back up trailer when off road due to the automatic backing system. The brakes lock before the trailer starts to move backwards. There needs to be something to disable the system when backing (like inserting a steel pin in the trailer tongue to keep it from sliding back and engaging the auto-brake).

c. One driver commented: The trailer is not wide enough. When you back the trailer, you can't see it until it's too late to turn it where you want it to go.

d. One driver commented: This generator is easier to pull than the mil std 60 KW and other generators because it is much lighter. That's better on the 2 1/2-ton and 5-ton trucks used to tow the generator.

e. One driver commented: The big fuel tank in the bottom of the trailer is a good idea. However, it needs a fuel gauge on the trailer.

f. One driver commented: You need to bring the 15 KW up from the ground a little bit more. It's a little too low to be pulled by a 2 1/2-ton truck.

g. One driver commented: The trailer bounced very high when towed off-road, even with a full load of fuel.

6.1.3.15.5 Analysis

Analysis of the preceding results led to the identification of human factors problems and the classification of these problems into the following critical and non-critical categories:

a. Critical Problems

1. Problem: The generator has no fuel gauge to determine fuel level or fuel consumption.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: Place a fuel gauge on the operator's control panel.

2. Problem: It is difficult to adjust the frequency of the generator. The operator must use a wrench to loosen the speed control and then a screwdriver to turn it.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: The throttle should have a knob on it, so the operator can adjust the frequency more readily.

3. Problem: The lugs are too small for the cabling requirements of the generator. It is difficult to connect 3 or 4 cables to the lugs--as the Army must do sometimes.

Violations of MIL-STD-1472C: Sections 4.4(f) and 5.9.4.5

Recommendation: Enlarge the lugs, so that power connections are easier to make, are more accessible, and are easier to check. The lugs should be at least the same size as those used on mil std generators.

4. Problem: The power connection compartment is located beneath the operator's control panel in a highly trafficked area.

Violation of MIL-STD-1472C: Section 4.4(f)

Recommendation: Move the power connection compartment to the side of the acoustical box so the power cables will be in a less trafficked area.

5. Problem: The water/coolant fill is inadequately located inside the acoustical enclosure. The radiator sits so high that it is difficult to check and service it from inside the acoustical enclosure.

Violations of MIL-STD-1472C: Sections 4.4(f) and 5.9.4.5

Recommendation: The water/coolant fill should be placed on top of the acoustical box, so the radiator can be checked and serviced externally.

6. Problem: The oil drain on the outside of the acoustical box sits at a higher level than the oil pan. The oil will not drain out because it cannot flow uphill. Consequently, changing oil is virtually impossible.

Violations of MIL-STD-1472C: Sections 4.4(f) and 4.4(m)

Recommendation: Redesign the lubrication system so that the oil drain is lower than the oil pan.

7. Problem: The trailer is too small and lightweight for the generator. It sits too low to the ground and the fuel tank is right on bottom of the trailer. Drivers must worry about puncturing the fuel tank when they travel over rough terrain. It would be difficult to locate the generator in place on hilly terrain. The hook-up mechanism and landing leg are not sturdy enough for use during field maneuvers.

Violations of MIL-STD-1472C: Sections 4.9 and 5.12.8.1

Recommendation: The trailer should be redesigned so that it sits higher off the ground; is wider, heavier, and sturdier; has a sturdier hook-up mechanism; has a sturdier landing leg; etc. The center-of-gravity of the generator/trailer should be determined and adjusted (via design or positioning changes) so that the generator/trailer would be able to complete tactical missions that require cross-country travel. Another option (besides redesign) is to mount the generator on a sturdier, military standard trailer.

8. Problem: The hydraulic brake system for the generator/trailer is inadequate. The brakes have a tendency to lock-up when a driver tries to back up, and when he drives over dirt or muddy roads.

Violation of MIL-STD-1472C: Section 4.9

Recommendation: The hydraulic brake system should be improved so that the mobility of the generator/trailer is not degraded. Another option is to replace the hydraulic brake system with an air brake system.

b. Non-critical Problems

1. Problem: The operator's panel lights cannot be extinguished during a blackout condition. The lights are adequate in the sense that you can see the whole panel, but inadequate in the sense that light discipline is impossible during tactical situations.

Violations of MIL-STD-1472C: Sections 4.4(h), 5.1.1.5, and 5.2.1.2.1.1

Recommendation: Use 3 or 4 external white lights on the operator's panel and low luminance, integral red lights for all gauges. The brightness of all lights should be adjustable and all lights should be extinguishable with on-off switches. This light configuration would allow maximum flexibility for operating during daytime, nighttime, and blackout conditions.

2. Problem: The batteries are difficult to access for maintenance purposes.

Violations of MIL-STD-1472C: Sections 4.4(f) and 4.9.4.5

Recommendation: Create a separate compartment for the batteries. The compartment should have its own access door so the operator can slide the batteries in and out easily. The batteries should be mounted side-by-side so they can be accessed individually without difficulty.

3. Problem: The engine must be shut down to check the oil. This requirement may interfere with tactical considerations.

Violation of MIL-STD-1472C: Section 4.4 (m)

Recommendation: Redesign the lubrication system so the oil may be checked and replenished while the engine is running, as well as while it is idle. The dipstick should be redesigned so it can be read under both conditions.

6.1.3.16 Manufacturer A, 30 kW, 60 Hz Generator, Modified with Baffling on Doors and Exhaust

6.1.3.16.1 Ratings Made By Three Operators

a. Environment. Two operators gave "Somewhat too high" ratings for the noise levels of the generator with the baffles and doors closed. Two operators gave "Somewhat too high" and "Much too high" ratings for the noise levels with the baffles and doors open. The three operators gave "Adequate" ratings for the temperature level near the generator during normal operations. The three operators gave "About right" ratings for the daytime and nighttime light levels at the operator's panel during normal conditions, and for the nighttime light levels achieved by red lens flashlights at the operator's panel during blackout conditions.

b. Indicator Lights. The three operators were satisfied with the indicator lights. They gave "Adequate" and "Very Adequate" ratings for each item in this section.

c. Gauges. The three operators were satisfied with the gauges. They gave "Adequate" and "Very Adequate" ratings for each item in this section.

d. Controls. The three operators were satisfied with the controls. They gave "Adequate" and "Very Adequate" ratings for each item in this section.

e. Power Connections. There was a great deal of variability among the ratings given for this section. The three operators gave "Adequate" and "Very Adequate" ratings for the labeling of lugs and the size of lugs. Two operators gave "Inadequate" and "Very Inadequate" ratings for the spacing between lugs. One operator gave "Inadequate" ratings for accessibility and ease of connecting cables.

f. Equipment Location. In general, the operators gave "Adequate" and "Very Adequate" ratings for all items relating to the location of equipment.

g. Workspace and Storage Space. In general, the operators gave "Adequate" and "Very Adequate" ratings for all items relating to workspace and storage space.

h. Operational Procedures. The three operators gave "Easy" and "Very Easy" ratings for stopping generator normally and preparing generator for transit. No "Difficult" or "Very Difficult" rating was given for any item in this section.

i. Maintenance Procedures. The three operators gave "Easy" or "Very Easy" ratings for the ease of checking the radiator. Two operators gave "Very Easy" ratings for most of the other items. One operator gave a "Difficult" rating for servicing the batteries.

j. Operator's Manual. There was a great deal of variability in the ratings given for the operator's manual. Although no "Inadequate" or "Very Inadequate" rating was given, one operator gave overall ratings of "Marginal" for the manual's accuracy and the manual's effectiveness.

k. Tools. Two operators gave "Adequate" and "Very Adequate" ratings for the two items pertaining to normally-issued tools. The other operator gave "Not Applicable" responses for the same two items.

l. Trailer. The three operators gave "Adequate" and "Very Adequate" ratings for all items, except "Size of lugs", "Connections on lugs", and "Protective cover over lugs." One operator gave "Inadequate" ratings for the size of the lugs and the connections on the lugs. One operator gave a "Neither Inadequate Nor Adequate" rating for the protective cover over the lugs.

6.1.3.16.2 Comments Made By Three Operators

a. Environment

1. One operator commented: The noise level with baffles and doors closed is somewhat too high. It's somewhat quieter than the others, but it's still somewhat noisy. If you're hiding out from someone in a tactical situation, they'd be able to hear the generator.

2. One operator commented: The vibration level is somewhat too high. It shakes me all around when I'm standing on it.

3. One operator commented: The panel lights on the operator's panel are excellent for nighttime operations. The interior lights are non-existent.

4. One operator commented: A red lens flashlight is all that is needed to correctly inspect the equipment at night. The main circuit breaker light is an excellent warning light to personnel close to the generator. The dimmers on them are an excellent idea.

b. Indicator Lights. One operator commented: The panel light switch may confuse people and cause problems in blackout situations. A red lens flashlight can correct this problem easily.

c. Gauges. One operator commented: I have never had any problems with the gauges on these generators.

d. Controls

1. One operator commented: The only thing I have noticed is that the frequency adjust knob on the instrument panel never makes a difference—i.e., it does not increase or decrease the frequency.

2. One operator commented: The toggle switches are excellent. They are easy to troubleshoot and are hardly ever damaged.

e. Power Connections

1. One operator commented: The spacing between the lugs is inadequate. The wrench given to tighten the nuts is made of plastic or fiberglass material. It tends to chip away because of poor space to turn the wrench between the lugs.

2. One operator commented: There is not enough space around and between the lugs to hook-up the size of cables I need to hook-up. The lugs themselves are big enough.

f. Equipment Location. No comments were made concerning the location of equipment.

g. Workspace and Storage Space. One operator commented: The 30 KW military type generator works real well on this type of trailer. There is just the right amount of space for everything, not too much or too little.

h. Operational Procedures

1. One operator commented: The handles on the doors are a problem. We already lost two of them and they're new. What they have on it right now just falls right out (i.e., the nuts). Once they start trying to seat themselves, the retainer comes right off. There is a spacer between the two latches and the handle; once the spacer is gone, the door won't relatch. They should have put a cotter pin in back.

2. Two operators commented: The door panel hooks are hard to close and open. The doors should be redesigned.

3. One operator commented: The access doors will not remain open when they're folded back and latched on top of the unit.

i. Maintenance Procedures

1. One operator commented: There was excessive oil in the exhaust. Also, the unit consumed an excessive amount of oil. We found no oil leak.

2. One operator commented: The radiator was contaminated by some kind of engine sealant compound.

j. Operator's Manual

1. One operator commented: The cable description and hook-up procedures are not explained clearly.

2. One operator commented: The PMCS tables do not always explain what to look for and list all the parts involved. It sometimes leaves out some important parts.

k. Tools. One operator commented: The wrench given to tighten the nuts is made of a plastic or fiberglass material which tends to chip away because of poor space to turn the wrench between the lugs.

1. Trailer. One operator commented: The 30 KW military type generator seems to work real well on this type trailer. There is just the right amount of space for everything, not too much or too little.

6.1.3.16.3 Ratings Made By One Driver

a. The driver gave "Very Easy" ratings for all towability items, except "Tow the generator and trailer on gravel roads at speeds exceeding 25 mph." He rated this item as "Did Not Perform."

b. The driver gave "Very Adequate" ratings for all items relating to the design features of the trailer, except "Design features for mounting trailer safely." He rated this item as "Adequate."

6.1.3.16.4 Comments Made By One Driver

a. The driver commented: Of all the quiet generators, this type trailer is the easiest to tow and maneuver. The other trailer types do not have long enough tongues for good maneuverability.

b. The driver commented: This type trailer size was very adequate for the generator. My only problem was with opening and closing the side panels.

6.1.3.16.5 Analysis

Analysis of the preceding results led to the identification of human factors problems and the classification of these problems into the following critical and non-critical categories:

a. Critical Problems

1. Problem: The noise levels with access doors closed and with them open are too high for tactical operations--i.e., dB(A) at one foot from the opened, control panel door is 99.

Violation of MIL-STD-1472C: Section 5.8.3.1

Recommendation: Before further consideration is given to this generator, the Army should retrofit it with a better acoustical package.

2. Problem: The power connections compartment is too cramped. There is not enough space between the lugs to turn the lug nuts with the normally-issued, fiberglass wrench. The fiberglass tends to chip away because of the inadequate space for turning. In addition, it is difficult to connect 3 or 4 large power cables to the lugs--as the Army must do sometimes.

Violations of MIL-STD-1472C: Sections 4.4(f) and 5.9.4.5

Recommendation: Enlarge the power connections compartment to make the lugs more accessible.

3. Problem: The access doors are too difficult to open and close for normal maintenance and emergency purposes. The multiple-turn latches are slow to operate and unreliable as a means of closure. There is no way to tell how well the doors are latched, since the operator can feel no positive locking action. In addition, the fold-up design and gravity-latch mechanism for keeping the doors in the "opened" position are safety hazards (i.e., opened doors could be accidentally bumped and could fall on the operator or other personnel in the area).

Violations of MIL-STD-1472C: Sections 4.4(m), 5.9.9.2, 5.9.9.4.1(b), 5.9.10.2, and 5.9.12.9

Recommendation: The access doors should be self-supporting so they can be opened quickly and easily. They should be hinged on one side and latched on the other (with tongue-and-slot catches). This configuration would allow the doors to be opened to the sides of the generator. The doors should have positive locks or braces to secure them when they are open. [Presently the door panels have hinges on top and multiple-turn catches on bottom. When they are in the "opened" position, they are folded and latched to the top of the generator.]

b. Non-critical Problem

1. Problem: The operator's manual does not clearly describe the power cables, the terminal area, the labels on lugs, and the procedures for connecting the power cables to the generator.

Violation of MIL-STD-1472C: Section 4.1

Recommendation: The operator's manual should give more details concerning the equipment and procedures for making power connections.

6.1.3.17 Manufacturer AW, 30 kW, 60 Hz Generator

6.1.3.17.1 Ratings Made By Two Operators

a. Environment. The two operators gave "Acceptable" ratings for the noise levels of the generator when the baffles and doors were closed and when they were open. The two operators gave "Acceptable" ratings for the vibration level and temperature level near the generator during normal operations. The two operators gave "About right" ratings for the daytime light levels at the operator's panel during normal conditions. One operator gave "Somewhat too low" ratings for the nighttime light levels at the operator's panel during normal operations and during blackout conditions.

b. Indicator Lights. In general, the operators gave "Adequate" and "Very Adequate" ratings for all items relating to indicator lights.

c. Gauges. The two operators gave "Adequate" ratings for the labels and the timeliness of information. One operator gave an "Inadequate" rating for the location of gauges.

d. Controls. The two generators gave "Adequate" and "Very Adequate" ratings for all items, except the accessibility of the throttle. One operator rated the latter as "Inadequate."

e. Power Connections. The two operators gave "Adequate" ratings for all items except "Accessibility" and "Ease of connecting cables." One operator rated the accessibility of the lugs as "Inadequate."

f. Equipment Location. In general, the operators gave "Adequate" and "Very Adequate" ratings for the location of all items of equipment, except the location of the operator's control panel, the fuel fill, and the oil fill. One operator rated the location of the latter three items as "Inadequate."

g. Workspace and Storage Space. The two operators gave "Adequate" ratings for the amount of workspace within the acoustical enclosure, the amount of storage space for tools, and the amount of storage space for grounding rods. One operator gave "Inadequate" ratings for the amount of workspace outside the acoustical enclosure and the amount of storage space for spare parts.

h. Operational Procedures. In general, the operators gave "Easy" and "Very Easy" ratings for all items, except "Set up generator and prepare for starting" and "Prepare generator for transit."

i. Maintenance Procedures. In general, the operators were satisfied with the ease of performing maintenance. The two operators gave "Easy" and "Very Easy" ratings for "Check load wire attachment", "Check ground terminal", "Check instruments for normal operation", "Replace lamps and fuses", "Check engine oil", "Change engine oil", "Service radiator", and "Check fuel filter". One operator gave an "Inadequate" rating for refueling the generator.

j. Operator's Manual. An operator's manual was present with the generator; however, neither of the operators used it. The ratings made in this section were not meaningful.

k. Tools. Only one operator gave ratings for the items in this section. He gave "Adequate" ratings for both items.

l. Trailer. The two operators gave "Adequate" ratings for the following items: Height of chassis above ground, Tire size, Location of power box on trailer, Suitability of power box for general use, Fuel storage, and Brakes. One operator gave "Inadequate" and "Very Inadequate" ratings for "Overall Size and Weight of Trailer", "Tire configuration on each side", "Hook-up mechanism", "Labeling of lugs", and "Design features for mounting trailer safely."

6.1.3.17.2 Comments Made By Two Operators

a. Environment

1. One operator commented: For daytime operations, sunlight provides enough light at the operator's panel. For nighttime operations, the meters should have more lighting.

2. One operator commented: The nighttime light levels achieved by the red lens flashlight are somewhat too low. You have to point the red lens at exactly the right place you are working on. It makes it hard if two instruments are to be checked at the same time.

b. Indicator Lights

1. One operator commented: The indicator lights are too high on the generator. In fact, the entire operator's panel is too high off the ground.

2. One operator commented. The light system is alright for the generator.

c. Gauges

1. One operator commented: The gauges are too high off the ground. If possible, put them at eye-level, or just above eye-level, so shorter people won't have to get on the step to read the instruments. The operator should be able to read the gauges while he is standing on the ground. The operator's panel is higher than the one on the old 30 KW generator.

2. One operator commented: The location of the gauges is very adequate. They are in the open (i.e, clear) -- so you don't have to go searching for them.

d. Controls

1. One operator commented: The type of control is very adequate. All you have is a bunch of toggle switches, so they're easy to work with. It's easy to start the generator up and run it.

2. One operator commented: The accessibility of the throttle is inadequate. It is placed in a tight space, way back in a hole. It is hard to hold on to and to work with. The old 30 KW has a throttle that's out in the open and easier to work with.

e. Power Connections. No comments were made relating to the items in this section.

f. Equipment Location

1. One operator commented: The location of the fuel fill is inadequate. It's in a hole. It's hard to get the nozzle in there and it's hard to keep it in while refueling. When you get your hands in there to push the lever on the nozzle, your hands get scraped and bumped. This problem does not exist on the old 30 KW generators.

2. One operator commented: The location of the water/coolant fill is very adequate. You don't have to go into the equipment to fill it.

3. One operator commented: The location of the operator's control panel is inadequate. First of all, it's mounted too high on the generator. Second, it's mounted on the side of the generator, rather than on the rear —like the old 30 KW's are. A rear location would be better, because it's all there together at the back.

4. One operator commented: The location of the batteries is "Very Adequate." You don't have to lift them up and out, or up and down. They're within normal arm length of pulling them out. They're perfect.

g. Workspace and Storage Space. One operator commented: The platforms, walking spaces, footholds, and handholds on the generator/trailer are inadequate. There are not enough spaces for you to step on, like on the old 30 KW trailer. There are not enough handholds to get ahold of when you are going to lift the trailer tongue. There are not enough walkspaces.

h. Operational Procedures. Two operators commented: It was very difficult to hook up the generator/trailer to the truck. The wrong type of trailer is used for this generator. There is no crank on the trailer, so it took 7 guys to lift it onto the truck. The new modified generator/trailer is dangerous because guys can't hold the tongue up too long. Also, it is very hard to move the heavy trailer over rocks to get to the hook on the truck. The trailer on the old 30 KW has a crank, so all you have to do is crank it up, push it a little bit, and then crank it back down onto the hook. This old type trailer should have been used with the new type generator.

i. Maintenance Procedures

1. One operator commented: The generator is hard to refuel, but it is easy to check and fill with oil, and to check batteries.

2. One operator commented: In order to perform maintenance on the generator, you have to remove too many panels to get to the equipment. The cover and insulation should be connected together and be mounted with hinges--similar to the way the old 30 KW doors are mounted. This would make them easy to open and close.

j. Operator's Manual. No comments were made relating to items in this section.

k. Tools. No comments were made relating to the items in this section.

l. Two operators commented: The trailer has no crank, so there was no way to lift it onto the truck. The trailer is the same type as that used with the MIL STD 5 KWS. That's not good because you need 5 to 10 people just to lift the trailer and hook it up. You should change the hook-up mechanism on this trailer or use a trailer like the ones on old 30 KW generators.

6.1.3.17.3 Ratings Made By One Driver

a. The driver gave "Easy" ratings for the towability of generator/trailer on paved roads at speeds below 25 mph and above 25 mph. He gave an "Easy" rating for the towability around curves on paved roads. The driver gave a "Difficult" rating for the towability of the generator/trailer on cross-country routes.

b. The driver gave "Adequate" ratings for the following items: Length of trailer, Width of trailer, Height of chassis above ground, Tire size, Hook-up mechanism, and Brakes. The driver gave "Inadequate" ratings for the following items: Overall Size and Weight of Trailer, Tire configuration on each side, and Design features for mounting trailer safely.

6.1.3.17.4 Comments Made By One Driver

a. One driver commented: The trailer is too narrow. It needs double wheels on each side like on the old 30 KW trailer.

b. One driver commented: The generator/trailer doesn't have enough handles, steps, and other features for mounting the trailer safely.

6.1.3.17.5 Analysis

Analysis of the preceding results led to the identification of human factors problems and the classification of these problems into the following critical and non-critical categories:

a. Critical Problems

1. Problem: The access doors are too difficult to open and close for normal maintenance and emergency purposes.

Violations of MIL-STD-1472C: Sections 4.4(m), 5.9.9.2, 5.9.9.4.1(b), 5.9.10.2, and 5.9.12.9

Recommendation: The outer access doors should be self-supporting so they can be opened quickly and easily. They should be hinged on one side and latched on the other (with tongue-and-slot catches). The outer doors should have positive locks or braces to secure them when they are in the "opened" position. The inner access doors should be pop-out doors (with tongue-and-slot catches on both sides).

2. Problem: The trailer is too narrow for the generator and is not sturdy enough (due to its size and its having only one tire per side of the generator). It is difficult to tow the generator/trailer cross-country.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: Another type of trailer should be used with this generator. The trailer should have features similar to those on the old mil std 30 KW trailer--i.e., two tires per side, a crank, adequate steps and walkspaces, etc.

3. Problem: The hook-up mechanism for the trailer is very inadequate. There is no crank on the trailer, so it takes 7 or 8 soldiers to lift the trailer tongue onto the tow vehicle. In addition, it is very difficult for soldiers to move the heavy trailer over rocks--getting it to and from the hook.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: Another type of trailer should be used with this generator. The trailer should have features similar to those on the old mil std 30 KW trailer--i.e., a crank, adequate steps and walkspaces, two tires per side, etc.

b. Non-critical Problems

1. Problem: The gauges on the operator's panel do not have adequate lighting for nighttime or blackout conditions.

Violations of MIL-STD-1472C: Sections 4.4(h), 5.1.1.5, and 5.2.1.2.1.1

Recommendation: Use 3 or 4 external white lights on the operator's panel and low luminance, integral red lights for all gauges. The brightness of all lights should be adjustable and all lights should be extinguishable with on-off switches. This light configuration would allow maximum flexibility for operating during daytime, nighttime, and blackout conditions.

2. Problem: The operator's control panel is too high off the ground. While standing on the ground, average-height males and females cannot reach the controls readily nor can they view the gauges from a proper angle. A step has been provided in front of the control panel, but it is too high off the ground and very inconvenient to use.

Violations of MIL-STD-1472C: Sections 3.1, 5.2.1.4.1, 5.2.1.4.2, 5.1.2.3.8, and 5.7.2.3

Recommendation: Lower the operator's control panel so that shorter people, as well as taller people, can operate the equipment while standing on the ground. The gauges should be at eye-level, or just above eye-level.

3. Problem: The throttle is not readily accessible. It is placed in a tight space, way back in a hole. It is hard to hold on to and difficult to work with.

Violations of MIL-STD-1472C: Sections 4.4(f) and 5.9.4.5

Recommendation: The throttle should be placed out in the open so it's easier to work with.

4. Problem: The fuel fill is not readily accessible. It is located outside the acoustical enclosure, but it's placed in a recessed hole. It's hard to get the fuel nozzle in the recessed area and it's hard to keep it in while refueling.

Violations of MIL-STD-1472C: Sections 4.4(f) and 5.9.4.5

Recommendation: The fuel fill should be placed out in the open so it's easier to work with.

5. Problem: The platforms, walking spaces, footholds, and handholds on the generator/trailer are inadequate. There are not enough places to step on and walk on. There are not enough handholds for lifting the trailer tongue.

Violations of MIL-STD-1472C: Sections 4.4(d) and 4.4(i)

Recommendation: Redesign the trailer so that there is an adequate amount of workspace around the generator or use a different sized trailer.

6.1.3.18 Manufacturer AQ, 30 kW, 60 Hz Generator

6.1.3.18.1 Ratings Made By One Operator

a. Environment. The operator gave "Much too low" ratings for the noise levels of the generator when the baffles and doors were closed and when they were open. The operator gave "Acceptable" ratings for the vibration level and temperature level near the generator during normal operations. The operator gave "About right" ratings for the daytime light level and the nighttime light level at the operator's panel during normal conditions. The operator stated that operator panel lights were not needed for nighttime operations and that the nighttime light levels achieved by red lens flashlights were "About right."

b. Indicator Lights. The operator gave "Inadequate" ratings for all items in this section.

c. Gauges. The operator gave "Inadequate" ratings for all items in this section.

d. Controls. The operator gave "Neither Inadequate Nor Adequate" ratings for the first five items in this section. He failed to give ratings for "Labels" and "Accessibility."

e. Power Connections. The operator gave "Neither Inadequate Nor Adequate" ratings for all items in this section.

f. Equipment Location. The operator gave "Neither Inadequate Nor Adequate" ratings for all items in this section.

g. Workspace and Storage Space. The operator gave "Neither Inadequate Nor Adequate" ratings for all items in this section.

h. Operational Procedures. The operator rated most of the items in this section as "Neither Difficult Nor Easy." However, he gave "Very Easy" ratings for transporting the generator and operating the generator while performing other duties.

i. Maintenance Procedures. The operator gave "Easy" and "Very Easy" ratings for all the items in this section, except "Replace lamps and fuses", "Service batteries," and "Replace fuel filter." The operator rated the latter three items as "Did Not Perform."

j. Operator's Manual. The operator was displeased with most aspects of the manual. He gave overall ratings of "Very Inaccurate", "Very Incomplete", and "Very Ineffective."

k. Tools. The operator gave "Neither Inadequate Nor Adequate" ratings for the adequacy of normally-issued tools for performing PMCS and troubleshooting.

l. Trailer. The operator was displeased with most aspects of the trailer. He gave "Neither Inadequate Nor Adequate" ratings for "Overall Size and Weight of Trailer," "Length of Trailer," "Width of Trailer", and "Design features for mounting the trailer safely." All other items were rated "Inadequate" and "Very Inadequate."

6.1.3.18.2 Comments Made By One Operator

a. Environment. The operator commented: The noise level was low. It was really quiet. It was acceptable.

b. Indicator Lights. No comments were made concerning this section.

c. Gauges. The operator commented: First, the light went out on the fuel gauge, and then the gauge stopped working.

d. Controls. No comments were made concerning this section.

e. Power Connections. No comments were made concerning this section.

f. Equipment Location. No comments were made concerning this section.

g. Workspace and Storage Space. The operator commented: I keep the manual in the van, and would do so even if I had a lockable box on the generator.

h. Operational Procedures. The operator commented: I operated in MOPP gear for 6 hours on the exercise. It was raining, and it was difficult to see out of the mask when refueling and trying to see the fuel fill. But it is hard to see through the mask whether it is raining or not.

i. Maintenance Procedures. No comments were made concerning this section.

j. Operator's Manual. The operator commented: For people who have never been trained on the generator, it is difficult to understand the manual. The manual is O.K. if you have already been trained on the generator.

k. Tools. The operator commented: We didn't need any tools. We had them if we needed them because we are a maintenance section.

1. Trailer

1. The operator commented: I thought we might lose the trailer and generator several times in the field, because of the terrain we had to go through. We broke an air line once.

2. The operator commented: With the dual wheels on either side, the trailer is too wide for the places we have to go through in the field.

3. The operator commented: For some of the places where we had to put the generator, it was difficult to get the cable in underneath and to the lugs. It would be easier to have a junction box on the trailer.

4. The operator commented: We were not allowed to keep fuel storage cans on the trailer when we were operating the generator in the field.

5. The operator commented: The hand brake on the trailer is very difficult to release. It may only need an adjustment.

6.1.3.18.3 Ratings Made By One Driver

a. The driver gave "Very Easy" ratings for all items relating to towability of the generator/trailer.

b. The driver gave "Neither Inadequate Nor Adequate" ratings for "Overall Size and Weight of the Trailer" and "Tire configuration on each side." Most of the other items were given "Inadequate" and "Very Inadequate" ratings.

6.1.3.18.4 Comments Made By One Driver

a. The driver commented: I thought we might lose the trailer and generator several times in the field, because of the terrain we had to go through. We broke an air line once.

b. The driver commented: With the dual wheels on each side, the trailer is too wide for the places we have to go through in the field.

c. The driver commented: The hand brake on the trailer is very difficult to release. It may only need an adjustment.

6.1.3.18.5 Analysis

Analysis of the preceding results led to the identification of human factors problems and the classification of these problems into the following critical and non-critical categories:

a. Critical Problems

Problem: The operator reported that an air line on the trailer broke during the field exercise.

Recommendation: Reconsider the location of the air lines and relocate them if necessary to insure that they are not in such a position as to be damaged by traversing rough terrain.

b. Non-critical Problems

1. Problem: It was somewhat difficult to run a power cable under the rear baffle and into the terminal area for connecting to the lugs.

Violations of MIL-STD-1472C: Sections 4.4(d) and 4.4(m)

Recommendation: Install a junction box on the trailer so that a power cable can be permanently hooked up to the lugs on the generator itself and all cable hook-ups in the field can be accomplished via the junction box.

2. Problem: The operator reported that the trailer was too wide to maneuver through all of the places he had to go in the field.

Violations of MIL-STD-1472C: Section 4.9

Recommendation: Reconsider the width of trailer and its functionality in a field environment.

3. Problem: The hand brake on the trailer was very difficult to release.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: Reconsider the design of the hand brake and incorporate an adjustment mechanism if one is not currently part of the design.

6.1.3.19 Manufacturer G, 30 kW, 60 Hz Generator

6.1.3.19.1 Ratings Made by Four Operators

a. Environment. In general, the operators gave "Acceptable" ratings for the noise levels of the generator when the baffles and doors were closed and "Somewhat too high" ratings when the baffles and doors were open. The four operators gave "Acceptable" ratings for the vibration level and temperature level near the generator during normal operations. In general, the operators gave "About right" ratings to daytime and nighttime light levels at the operator's panel during normal conditions. Three operators gave "About right" ratings for nighttime light levels achieved by red lens flashlights during blackout conditions.

b. Indicator Lights. In general, the operators gave "Adequate" and "Very Adequate" ratings for the indicator lights.

c. **Gauges.** In general, the operators gave "Adequate" and "Very Adequate" ratings for the gauges. However, one operator gave "Very Inadequate" ratings for the brightness of the gauges at night and the location of gauges.

d. **Controls.** In general, the operators gave "Adequate" and "Very Adequate" ratings for the controls.

e. **Power Connections.** The four operators gave "Adequate" and "Very Adequate" ratings for the labeling of lugs and the size of lugs. However, they were somewhat dissatisfied with the spacing between lugs, accessibility, and ease of connecting cables. Two operators gave "Very Inadequate" ratings for accessibility and ease of connecting cables.

f. **Equipment Location.** The four operators gave "Adequate" and "Very Adequate" ratings for the location of the following items: Operator's control panel, Indicator lights, Start-Stop switch, and Fuel fill. Three operators gave "Inadequate" and "Very Inadequate" ratings for the location of the water/coolant fill. Two operators gave "Inadequate" and "Very Inadequate" ratings for the location of the oil fill. The ratings for the other items in this section were highly variable.

g. **Workspace and Storage Space.** The ratings for the two "workspace" items in this section were highly variable. Two operators gave "Inadequate" ratings and two gave "Adequate" ratings for the amount of workspace within the acoustical enclosure. One operator gave an "Inadequate" rating and two operators gave "Adequate" ratings for workspace outside the acoustical enclosure, i.e., the design of platforms, walking spaces, footholds, and handholds for mounting the generator/trailer. The operators were more consistently dissatisfied with the storage space on this generator. Two operators gave "Inadequate" and "Very Inadequate" ratings for items related to the amount of storage space provided for fuel cans, tools, spare parts, manuals, and grounding rods.

h. **Operational Procedures.** In general, the operators were satisfied with the generator's ease of operation during normal conditions. Three operators gave "Easy" and "Very Easy" ratings for all non-MOPP items in this section, except "Start up generator manually," a non-applicable item for this generator.

i. **Maintenance Procedures.** In general, the operators were dissatisfied with the generator's ease of maintenance during normal conditions. Three operators gave "Difficult" and "Very Difficult" ratings for checking engine oil. Three operators gave "Difficult" ratings for checking the radiator. Two operators gave "Difficult" and "Very Difficult" ratings for performing overall check of general system, checking oil filter, and checking for fuel leaks. One operator gave "Difficult" and "Very Difficult" ratings for checking batteries, servicing batteries, and servicing radiator. Those operators who did not rate the internal PMCS procedures as being "Difficult" and "Very Difficult", rated these items in the "Did Not Perform" category. In general, the only items rated "Easy" and "Very Easy" were those with external PMCS procedures, such as checking load wire attachment, checking ground terminal connection, checking instruments for normal operation, and refueling the generator.

j. Operator's Manual. Two operators stated that manuals were provided and two operators stated that they were not provided. The two operators who had access to manuals had no complaints relating to its organization, description of equipment, explanation of procedures, understandability, etc. However, a generalization should not be made from the ratings of such a small sample.

k. Tools. In general, the operators gave "Adequate" and "Very Adequate" ratings to the normally-issued tools for performing PMCS and troubleshooting.

1. Trailer. In general, the operators were satisfied with various aspects of the trailer. The four operators gave "Adequate" and "Very Adequate" ratings for tire size, hook-up mechanism, and brakes. Three operators gave "Adequate" and "Very Adequate" ratings for the overall size and weight of trailer, shape of trailer (length, width, and height of chassis above ground), sturdiness of trailer, tire configuration on each side, and fuel storage. The ratings for the power box were highly variable.

6.1.3.19.2 Comments Made By Four Operators

a. Environment

1. One operator commented: Using panel lights at night did not allow a visual check of the fuel gauge. I had to use a flashlight to check it at night.

2. One operator commented: The operator panel lights were good; you could see and read the panel very easily at night.

b. Indicator Lights. No comments were made about the indicator lights.

c. Gauges

1. One operator commented: All gauges were fine, except the fuel gauge. It should be moved or another light should be added so you can read it at night.

2. One operator commented: Bubble indicators should be added so you can just read off the oil level and the water/coolant level.

d. Controls. No comments were made about the controls.

e. Power Connections

1. Two operators commented: It is too cramped in the power connections compartment. Another door should be added to this compartment. The new hinged door should be placed on the left side of the generator (i.e., "left" when facing the operator's control panel at rear of unit). The rear door should remain, but it should be hinged so that it opens from left-to-right, instead of the current right-to-left movement for opening.

2. One operator commented: The power connections compartment should be enlarged. There is not enough room to put the plastic safety guard back on (over the lugs) when the power cables are hooked-up to generator. So, we just left it off.

f. Equipment Location

1. Three operators commented: The water/coolant fill is on top of the generator. You have to climb up there and carry your coolant with you. There are no steps or anything, so it's kind of a safety hazard. Suggestion: Mount a ladder on the side of the generator box for better access to the water/coolant fill on top.

2. Two operators commented: It takes too long to perform PMCS on this generator because the doors (inside and outside) are extremely hard to get off. It took me 1/2 hour to 1 hour just to check the oil. Suggestion: Replace the present screw-on access panels with hinged-opened, latch-locked doors (similar to the present rear doors on this generator). Pop-out doors should be used on the inside too, so the acoustical baffling is easy to get off.

g. Workspace and Storage Space

1. One operator commented: I don't know of any storage spaces. If there are some, they are very small.

2. One operator commented: I think you need storage space for grounding rods, manuals, fuel cans, hammer for driving grounding rod into ground, and other tools.

h. Operational Procedures

1. One operator commented: The generator is big, so it was difficult to locate it in place. The only thing that will pull it is a Deuce-and-a-Half, and you have to look around for a while to find a large enough spot to put it in.

2. One operator commented: I had no problems with it. I ran it 8 to 12 hours at a time with 75% load on it, and the temperature never went over 170°F. (At our training session for this generator, the instructor said not to worry if the engine temperature got up to 210°F and above, because these are hot-running generators.)

i. Maintenance Procedures

1. One operator commented: Getting the door panels off so you can do a PMCS is a pain. It takes 1/2 to 1 hour to check oil.

2. Two operators commented: The panels on the side of the generator should be easier to take off. To check engine oil, you have to pull off one of the side panels. The panels have several screws in them that take some time to take out. At nighttime, it is very hard. It is even harder to put the doors back on than it is to take them off. Suggestion: Either rotating handles or clip latches as on standard military generators are better. The clip latches are the best.

3. One operator commented: Checking the radiator is difficult because the water/coolant fill is on the top of the generator and there are no handholds or footholds on the side to help you mount it.

4. One operator commented: We had two maintenance problems in the field--a fuel leak and an engine overheat condition. The engine of one generator got up to 225°F because the acoustical foam inside the box became unglued, fell off, and blocked the air intake.

j. Operator's Manual. No comments were made about the manual.

k. Tools

1. One operator commented: The normally-issued tools for connecting power cables were very inadequate. There isn't enough room in the power connection compartment to turn the nuts with normally-issued tools. A specially designed tool should be issued or the power connections compartment should be enlarged.

2. One operator commented: I have a complete tool box filled with normally-issued tools which are very adequate for performing operator PMCS.

l. Trailer

1. One operator/driver commented: The generator/trailer is very, very top heavy. I almost turned mine over twice on rough terrain. One set of duals came completely off the ground.

2. One operator/driver commented: It is impossible to see the generator when the tow vehicle is going straight. Suggestion: Make trailer wider.

3. One operator commented: The trailer is too long. But, a longer trailer may be necessary since the generator is bigger than mil std generators.

4. One operator commented: The fender wall gets in the way of pulling maintenance on the wheels. You have to get another jack to jack up the fender wall so you can get the tire off. This is an inconvenience and a safety hazard, because no jack will reach that high--and you have to get some wood to build up a base on top of the jack.

5. One operator commented: You need a place to put fuel cans, or provisions for an auxillary fuel system with a fuel selector switch.

6.1.3.19.3 Ratings Made By Two Drivers

a. Both drivers gave "Easy" ratings to all items relating to towability, except that one driver rated "Tow the generator/trailer on gravel roads at speeds exceeding 25 mph" as "Not Applicable" and one driver rated "Back up with generator/trailer" as "Neither Difficult Nor Easy."

b. Both drivers gave "Adequate" and "Very Adequate" ratings to all items relating to the design features of the trailer, except that one driver rated "Overall Size and Weight of Trailer" as "Neither Inadequate Nor Adequate" and one driver rated "Tire Configuration On Each Side" as "Very Inadequate."

6.1.3.19.4 Comments Made By Three Drivers

1. One driver commented: The fender walls obstruct the pulling of wheels off the trailer.
2. One driver commented: The trailer is not very sturdy—i.e., it is top heavy. I almost turned mine over twice on rough terrain. One set of duals came completely off the ground.
3. One driver commented: It is impossible to see the generator/trailer when the tow vehicles is going straight. Suggestion: Make trailer wider.

6.1.3.19.5 Analysis

Analysis of the preceding results led to the identification of human factors problems and the classification of these problems into the following critical and non-critical categories:

a. Critical Problems

1. Problem: The access doors are too difficult to open and close for normal maintenance and emergency purposes. The screws on the outside and inside acoustical panels must be removed before the access doors can be taken off the generator. It takes between 1/2 hour and 1 hour to check the oil.

Violations of MIL-STD-1472C: Sections 4.4(m), 5.9.9.2, 5.9.9.4.1(b), 5.9.10.2, and 5.9.12.9

Recommendation: The outer access doors should be self-supporting so they can be opened quickly and easily. They should be hinged on one side and latched on the other (with tongue-and-slot catches). The outer doors should have positive locks or braces to secure them when they are in the "opened" position. The inner access doors should be pop-out doors (with tongue-and-slot catches on both sides).

2. Problem: The power connections compartment is too cramped. There is not enough room in the compartment to turn the lug nuts with normally-issued tools. In addition, it is difficult to connect 3 or 4 large power cables to the lugs—as the Army must do sometimes. Because the compartment is so cramped, the plastic safety guard will probably be left off when the power cables are hooked-up to the lugs.

Violations of MIL-STD-1472C: Sections 4.4(f) and 5.9.4.5

Recommendation: Either enlarge the power connections compartment or add another door to the compartment. If a new door is added, it should be placed on the left side of the generator (i.e., "left" when facing the operator's control panel at the rear of the unit). The rear door should remain, but it should be hinged so that it opens from left-to-right, instead of the current right-to-left movement for opening.

3. Problem: The generator/trailer is very tall, very narrow, very long, and very top-heavy. The unequal weight distribution causes problems during transport and placement. The narrow width causes problems during transport because the driver cannot see the generator/trailer when he is driving straight.

Violation of MIL-STD-1472C: Section 5.12.8.1

Recommendation: The center-of-gravity of the generator/trailer should be determined and adjusted (via design or positioning changes) so that the generator/trailer would be able to complete tactical missions that require cross-country travel.

4. Problem: The fender walls on the trailer are located too close to the tires. You have to jack up the fender to pull off the tires. This requirement would severely degrade the unit's mobility in a tactical situation.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: The fender walls on the trailer should be redesigned so that it is easier and quicker to change tires.

b. Non-Critical Problems

1. Problem: The lights on the operator's panel are not bright enough to allow a visual check of the fuel gauge at night.

Violations of MIL-STD-1472C: Sections 4.4(h), 5.1.1.5, and 5.2.1.2.1.1

Recommendation: Use 3 or 4 external white lights on the operator's panel and low luminance, integral red lights for all gauges. The brightness of all lights should be adjustable and all lights should be extinguishable with on-off switches. This light configuration would allow maximum flexibility for operating during daytime, nighttime, and blackout conditions.

2. Problem: There is no storage space on the generator.

Violation of MIL-STD-1472C: Section 5.9.1.2

Recommendation: Storage space should be provided for special tools, spare parts, fire extinguishers, grounding rods, fuel, oil, water, and other maintainability items. This space should have a lock on it so that pilferage may be prevented.

3. Problem: The water/coolant fill is located on top of the acoustical enclosure. There are no handholds or footholds to be used for mounting the generator. Thus, the generator was not designed for maintainability.

Violations of MIL-STD-1472C: Sections 4.4(f) and 5.9.4.5

Recommendation: Place handholds and footholds on the sides of the acoustical enclosure so the water/coolant fill will be more accessible.

4. Problem: The generator has no fuel selector switch, so it cannot run off an auxiliary fuel supply.

Violation of MIL-STD-1472C: Section 4.4 (m)

Recommendation: Place a fuel selector switch on the generator to increase its tactical flexibility.

6.1.3.20 Manufacturer H, 30 kW, 60 Hz Generator

6.1.3.20.1 Ratings Made By Twelve Operators

a. Environment. Ten operators gave "Acceptable" ratings for the noise levels of the generator when the baffles and doors were closed and when they were open. Eleven operators gave "Acceptable" ratings for the vibration level and temperature level near the generator during normal operations. Nine operators gave "About right" ratings for the daytime light levels at the operator's panel during normal conditions. Five of nine operators gave "About right" ratings for the nighttime light levels at the operator's panel during normal conditions. Seven of eight operators gave "About right" ratings for the nighttime light levels during blackout conditions.

b. Indicator Lights. In general, the operators gave "Adequate" and "Very Adequate" ratings for all items relating to indicator lights.

c. Gauges. In general, the operators gave "Adequate" and "Very Adequate" ratings for all items relating to gauges, except the location of the fuel gauge. Six operators gave "Inadequate" and "Very Inadequate" ratings for the location of this gauge.

d. Controls. In general, the operators gave "Adequate" and "Very Adequate" ratings for all items relating to the controls.

e. Power Connections. In general, the operators gave "Adequate" and "Very Adequate" ratings for all items relating to the power connections.

f. Equipment Location. In general, the operators gave "Adequate" and "Very Adequate" ratings for the location of all items of equipment, except the fuel gauge and fuel fill. Six operators gave "Inadequate" and "Very Inadequate" ratings for the location of the fuel fill. Five operators gave "Inadequate" ratings for the location of gauges--more specifically, the location of the fuel gauge.

g. Workspace and Storage Space. In general, the operators gave "Adequate" and "Very Adequate" ratings for the workspace within the acoustical enclosure, workspace outside acoustical enclosure, storage space provided for fuel cans, storage space provided for tools, and storage space provided for grounding rods. There was notable dissatisfaction with the amount of storage space for spare parts and manuals (i.e., 3 or 4 "Inadequate" and "Very Inadequate" ratings for each item).

h. Operational Procedures. In general, the operators gave "Easy" and "Very Easy" ratings for all items in this section except "Start up generator manually"--and no operator performed this procedure.

i. Maintenance Procedures. In general, the operators gave "Easy" and "Very Easy" ratings for the following items: Perform overall check of generator system, Check load wire attachment, Check engine oil, and Check radiator. In general, the operators gave "Difficult" and "Very Difficult" ratings for refueling the generator. A preponderance of "Did Not Perform" ratings was given for the following items: Replace lamps and fuses, Service batteries, Change engine oil, Check oil filter, Replace oil filter, Service radiator, Check fuel filter, and Replace fuel filter. All items under the "Unscheduled Maintenance Actions" section received a preponderance of "Did Not Perform" ratings.

j. Operator's Manual. The ratings for this section are difficult to interpret since some operators had access to a complete manual, some operators only had access to xeroxed copies of certain pages of the manual, and some operators did not have access to a manual or xeroxed copies of certain pages.

k. Tools. Eight operators gave "Adequate" and "Very Adequate" ratings to the normally-issued tools for performing PMCS. The ratings given for the troubleshooting items were quite variable.

l. Trailer. In general, the operators gave "Adequate" and "Very Adequate" ratings for all items relating to the trailer.

6.1.3.20.2 Comments Made By Twelve Operators

a. Environment

1. One operator commented: The nighttime light level was somewhat too low. When you check the generator at night, it is impossible to check the fuel gauge because of its location and the amount of light in this area. To get to the fuel gauge, you have to take off the side panel, pull out the inner baffles, and crawl inside the generator with a red lens flashlight. This task was totally impossible to do.

2. One operator commented: If you check the fuel gauge, oil, or radiator at night, there's not enough light after you take the doors off the right side. You need to use your flashlight to see the gauges, because they're set down in the well of the generator itself.

3. Two operators commented: The location and size of the fuel gauge were totally unacceptable. You can't see the fuel gauge without having to use a flashlight. Suggestion: Either put a small light inside the generator so you can see the fuel gauge or relocate the fuel gauge to the operator's panel where the other gauges are. With either one of these suggested modifications, you won't be bumping your head while trying to see the fuel gauge.

4. One operator commented: A small light is needed inside the generator, so an operator can check the fuel and oil levels.

5. One operator commented: Panel light levels without the aid of a flashlight were unacceptable on the top three gauges (voltmeter, ammeter, and frequency meter). The panel light levels for lower gauges were excellent.

6. One operator commented: When you check the oil level at each 12-hour shift change, the engine is somewhat too hot and you have to let it cool off before proceeding. You cannot reach over the engine block because it is too hot--you must go around to the other side.

7. One operator commented: You can't see the oil stick with the red lens very well. If you don't have a white light, you can't see where to put the dipstick back in. You even need a flashlight during the day if it's cloudy.

8. One operator commented: The noise level is a little too high for tactical operations. This generator is much improved over mil std generators, but it still should be a little quieter.

b. Indicator Lights

1. One operator commented: Since there is only one indicator light on this model (i.e., the alarm light), I can't fully comment on this section.

2. One operator commented: Alarm lights should differentiate between oil and water conditions. If my generator shuts down, I want to know precisely what went wrong, i.e., what went out of commission to cause the alarm light to come on in the first place.

c. Gauges

1. Ten operators commented: The fuel gauge is definitely in the wrong place. It is at the bottom on the inside. You have to take the doors off and then stick your head inside the engine compartment to look at the gauge. If the engine is hot, you could get burned. It should be placed on the indicator panel itself or on the outside of the body, so you can see it at a glance without having to get inside the generator. The present location is not practical for purposes of monitoring fuel consumption in the field.

2. One operator commented: The location of the fuel gauge is inadequate. As long as you have adequate light or a flashlight with you and it's fairly clean down where the gauge is, you could see it. But, being so far down and in such a small space, it was generally in the shadows or was too dusty to be read (since a lot of dirt accumulated in that area when we convoyed out). You have a hard time even getting down there to wipe the dirt off the gauge. Suggestion: Move the fuel gauge to a more accessible location, to where you can see it. It was just too far down to be read without some kind of flashlight. I recommend that you put it on the operator's panel like on other generators. If it is put on the engine, it should be mounted higher up so you can see it.

3. One operator commented: The fuel gauge was very inaccurate. I had one that showed 3/4 full when the tank was actually full.

4. One operator commented: The DC ammeter should be replaced with a "BTRY CONDITION" gauge similar to those found on 2 1/2-ton and 5-ton vehicles. Also, a "Percent Load" gauge should be added to the control panel.

d. Controls

1. One operator commented: The throttle is too hard to push.

2. One operator commented: The 3-position start switch on the generator is adequate and does a good job. But, I would prefer a key control system (with 3 positions) for starting and stopping the system, so I can control who starts and stops the generator. Also, I like the idea of having to use two hands to start the generator: one on the alarm bypass and one on the switch. With this procedure, you know you are doing it right because you can't do it with one hand. You can start the mil std generators with one hand.

e. Power Connections

1. One operator commented: The accessibility of the power connections is very adequate. I like them where they are; it's a very good place for them.

2. One operator commented: We need big wrenches to work on the big lug nuts.

3. One operator commented: In connecting a B unit to an A unit, we found poor accessibility to the Junction Box connections on the bottom side. Connectors are either too large or lugs are too small.

4. One operator commented: The lugs are too close together to hook up 3, 4, or more cables. The size of the lugs is fine; there just isn't enough room between the lugs. This problem exists on mil std generators too.

5. One operator commented: It is difficult to hook up a second generator to the switch box because the lugs are at a slant and you almost have to work upside down. We lost a lot of time during this hook-up procedure. Having a plug-in connector or a hock would be an improvement.

6. One operator commented: The wires in the cable are color-coded but the lugs are numbered or lettered. The manual should tell me what color to hook up to which number. Most operators don't have sufficient knowledge or accurate, easy-to-read technical manuals to know what colored wire goes to what terminal.

7. Two operators commented: The cover on the switch box will not close like it should. This could have caused serious injury to individuals removing the side doors and attempting to refuel the generator. If a metal fuel can had shorted across the exposed posts, a serious accident would have occurred.

8. One operator commented: If the power cable were brought out from the left side instead of the right side, you would not have to climb over it to get to the operator's panel. Another solution to the congestion up front is to have the panel door open the other way (i.e., from left to right).

f. Equipment Location

1. Five operators commented: The location of the fuel fill is very inadequate. Having to fill up those generators using 5-gallon cans, when the fuel fill is inside the acoustical box, you've got a chance to spill fuel all over the place. And, pouring fuel around a hot engine creates a fire hazard. The generator should have an external fuel fill--not only for ease of use but also for safety purposes.

2. Five operators commented: The location of the fuel gauge is inadequate. As long as you have adequate light or a flashlight with you and it's fairly clean down where the gauge is, you can see it. But, being so far down and in such a small space, it was generally in shadows or was too dusty to be read easily. A lot of dirt accumulated in that area when we convoyed out, but you couldn't get down there to wipe it off very easily. Suggestion: Move the fuel gauge to a more accessible location such as the operator's control panel.

3. One operator commented: There is fuel in the bottom of the generator out here. The fuel gauge is so poorly located that you can't tell how much fuel you are pouring into the generator from the 5-gallon cans. Everytime you have some overflow and sometimes you can pour as much as a gallon into the bottom of the trailer. The spillage can't drain out the rear unless you are on an incline. In most cases, the fuel just stays there inside the acoustical box. When you stick your head inside the engine compartment, you get overwhelmed by the fumes from the spilled fuel. Suggestion: The generator should have an external fuel fill.

4. One operator commented: The location of the water/coolant fill is inadequate because the radiator is too high. When checking the water/coolant level, it's hard to see how much water is in the radiator.

5. One operator commented: It is difficult to see the level of coolant. If the engine is running or is hot, it is very difficult to check the coolant level because of the location of the water/coolant fill, i.e., above the fan. This is a safety problem.

6. One operator commented: It is difficult to fill the radiator because of a lack of room within the acoustical box. The procedure is easier to accomplish on mil std generators, because the radiator on these is accessible from the top of the box.

7. One operator commented: The location of the oil fill is bad. First of all, you must take two doors off to get to it. Then, you have to contend with a bar in the same position as the oil fill. It's easy to bang your hands in there.

8. One operator commented: To check batteries, you have to stick your head in the housing area and it is hot in there. If the fender skirts are wet, you could slip and fall into the engine. Also, the tie down straps on the batteries are too wide--they cover up the indicators on one battery.

9. One operator commented: The oil fill is very close to the fuel fill. During daylight conditions, you can tell the difference between them; but at night under blackout conditions, it is possible to get them confused because they are so close together. Thus, it is possible to put oil in the diesel spout or vice versa during blackout conditions.

10. One operator commented: Because of the generator/trailer configuration (with control panel above trailer tongue), you cannot get to the control panel very easily. This is especially true if you have a camouflage net hanging over the front of the generator. Under these conditions, it is also difficult to open the door to the control panel. Suggestion: Move the control panel to either the side or the rear of the generator, so you don't have to crawl over the front of the trailer to get to the panel door.

11. Four operators commented: The control panel would be more accessible if it were relocated to the rear of the generator. In its present location, you have to crawl over the trailer tongue and power cables to get to the panel. An operator could fall off and hurt himself--especially at night or when it's muddy.

12. One operator commented: I like having the operator's panel in front because it is away from the exhaust on the back and I can camouflage over the back.

13. Two operators commented: The doors to the engine compartment are very inadequate. When you refuel, you've got to take the doors off while you're standing on the wheel well. There's no place to put the doors on the generator and it's hard to put the heavy and bulky doors down on the ground, especially if you're by yourself. Suggestion: Put hinges and a different type of latch on the doors so you don't have to take them completely off. The present latches can be turned too far in one direction, then they have to be turned completely back in order to refasten the doors.

14. One operator commented: The doors should have hinges because they are heavy, hard to tighten down, and hard to remove. If the spin-type door latches don't catch exactly right, the panels will fall off as you go down the road. To remove a door, you have to tilt it back, pull it off the lip, and set it aside. If you're in a confined area when you take a door off, you can easily get it hung up on bushes or camouflage net--causing you to fall off the generator or drop the door on your partner or yourself. Suggestion: Replace the spin-type door latches with flipper-type latches like the ones on mil std generators. These latches are a lot more efficient and are faster to open. We definitely need quick-opening doors in case we need to get inside the generator to put out a fire or take care of some other emergency.

15. One operator commented: The doors are pretty heavy and hard to lift, especially for some of our females.

g. Workspace and Storage Space

1. One operator commented: The workspace on the sides of the generator is inadequate. For example, the power box is in the area where you need to set a door down.

2. One operator commented: The amount of workspace within the acoustical enclosure is inadequate for servicing the generator with fuel and water.

3. One operator commented: There is inadequate space for storing items securely, such as tools and manuals.

4. One operator commented: The storage space for tools is inadequate. There is a small box in front for storing some ground rods, and that is all you can carry in it. We carry tools in our trucks, but if you have to move the trucks to another location, you won't have tools for the generator if you need them. Suggestion: A larger storage box is needed for storing sledge hammers, grounding rods, other tools, manuals, etc.

5. One operator commented: The types of items one would need to store on the generator include several quarts of oil, a lug wrench for making power connections, and a few wrenches and other tools.

6. One operator commented: I have space for two fuel cans. I need two more. I also need storage space for oil and fuel filters, and a manual. The location of storage space for pioneer tools, grounding rods, etc. is fine.

7. One operator commented: Normally, we keep the manuals and tools inside the vehicle that pulls the generator because there is more room in there and the equipment is more secure. I prefer this over keeping the manual and tools on the generator itself. You don't need storage space on the generator.

8. One operator commented: I recommend that the screen mesh on top of the generator have the edges placed under a frame, so that the ends won't be able to snag the camouflage or a tree limb (like they did during the exercise). The screen mesh on one generator was really bent out of shape.

h. Operational Procedures

1. One operator commented: The procedures for hooking up input from the second generator to the power distribution box are difficult because the lugs are at a slant and you almost have to work upside down. We lost a lot of time getting it hooked-up correctly. Having a plug-in connector or a hook would simplify these procedures. Also, the procedures for hooking-up output from the power distribution box are difficult and time consuming. The lugs are too close together to hook up 3, 4, or more cables. The size of the lugs is fine; there just isn't enough room between the lugs. This problem exists for mil std generators too.

2. One operator commented: It will be difficult and time consuming for operators wearing MOPP gear to prepare the generator for transit—due mainly to the difficulty of unhooking cables going into and out of the power distribution box.

3. One operator commented: The doors are too heavy for some people, especially when working in the confined area around the side of the trailer. Also, if you turn the door handles too much the washers will pop off, and it is real hard to put them back on. Suggestion: The doors should be hinged on one side and latched on the other so they will open and close more easily.

4. One operator commented: It takes too long to get to the circuit breaker inside the operator's panel for an emergency shut down because of the type of latch on the panel door, i.e., multiple-turn latches. The flip-type latch, like those on mil std generators, would be a lot more efficient and faster to use.

i. Maintenance Procedures

1. One operator commented: It is difficult to check oil when the engine is hot. I burned my hand and arm several times.

2. One operator commented: It is difficult to add fuel through the internal fuel fill because the doors are not hinged.

3. One operator commented: It is difficult to check the radiator and fuel filter because there is not enough room inside the box to do it.

4. One operator commented: The oil fill is very close to the fuel fill. During daylight conditions, you can tell the difference between them; but at night under blackout conditions, it is possible to get them confused. It is possible to put oil in the diesel spout or vice versa during blackout conditions.

5. One operator commented: To check batteries, you have to stick your head in the housing area and it is hot in there.

6. One operator commented: It is difficult to see the level of coolant in the radiator. If the engine is running or is hot, it is very difficult to check the coolant level because the water/coolant fill is above the fan. It is difficult to fill the radiator because of lack of room.

7. One operator commented: Checking for fuel leaks is difficult because the fuel tank sits so far down.

8. One operator commented: You have to pull the baffle out to check the oil. Most operators are starting to avoid putting back the front pin on the baffle--so it will be easier to get inside the generator. Also, the area around the dipstick is quite hot. There is not enough clearance between the dipstick and the block, so a potential burn hazard exists. If the dipstick were extended up above the oil filter, it would help the situation.

9. One operator commented: All of our test generators had fuel seeping out of the acoustical box. There was so much fuel standing inside that you didn't know if the seepage was from inside spillage or from a fuel leak (or both). The fuel fill should be on the outside of the box.

10. One operator commented: The doors should be hinged so they'd be easier to open. Trying to take the doors off at night is a problem. The locking mechanism didn't work well. People didn't know which way to tighten them, they tightened them too tight, etc.

j. Operator's Manual

1. One operator commented: I needed to find the fuel capacity of this generator in the manual, but couldn't find this information.

2. One operator commented: The manual was very good. Other operators just showed me how to start the generator and check the oil. I read the manual and figured out how to operate the thing myself, and taught the other people how to operate it.

3. One operator commented: I had a commercial manual on the generator, but not the engine. So, I could not find the fuel capacity of the system. I read the manual several times so I would know what to tell my operators. Too much maintenance-related detail was included for operators. It was difficult to understand the text because it was written for someone with electrical knowledge. The manual was over my head in most cases. Two things were missing in the manual: a PMCS table and an output wiring diagram for the cables.

k. Tools

1. One operator commented: The normally-issued tools for connecting power cables were inadequate. It would be better to provide a special wrench that fits the lugs--i.e., a box-end plastic tool specially designed for the lugs.

2. One operator commented: We needed a fiberglass lug wrench. Also, several screwdrivers and a crescent wrench would be good to have for any generator. Wrenches are needed to remove batteries. Screwdrivers are needed to get into the operator's panel to hook up the cables.

l. Trailer

1. One operator commented: The trailer configuration makes it slightly difficult to work in the engine compartment.

2. One operator commented: The generator does not fit well on the trailer, i.e., it is too long for the trailer. The generator sticks out from the trailer and the acoustical box has no protection for its rear.

3. One operator commented: The power box location and size (or size of power cable ends) are inadequate.

4. One operator commented: The only problem we had with this trailer was due to an operator's error--he inadvertently ran air into the emergency brake system, the holding tank. When the brakes locked up, he continued to drag the generator down the road and burned the brakes out.

5. One operator commented: Raising the trailer's tires into touring position is too time consuming.

6. One operator commented: The trailer is too large for this generator. This trailer is for a 100 KW generator; therefore, it takes more people than necessary to manhandle it. It usually takes 4 people to disconnect it. Suggestion: Use one-size smaller trailer.

7. One operator commented: I have space for 2 fuel cans on the generator. I need two more cans. I also need storage space for oil, fuel filter, and a manual. The storage space for pioneer tools, grounding rods, etc. is fine.

8. One operator commented: In a different site we should be able to configure the trailers so you can get all the way around them. The Golden Saber site was small, so we couldn't do it there.

9. One operator commented: The location of the power box on the trailer is inadequate. The power box sits at an angle, so you must work upside down to hook-up the second generator to the power box. Also, the labeling of lugs is very inadequate. You can't tell which wire from the vehicle goes to which lug. Also, the protective cover over lugs should be larger to accommodate 4 or 5 cables.

6.1.3.20.3 Ratings Made By Three Drivers

a. The three drivers gave "Easy" and "Very Easy" ratings for the towability of generator/trailer on paved and gravel roads at speeds below 25 mph and above 25 mph. The three drivers gave "Easy" and "Very Easy" ratings for the towability around curves on paved roads. One driver was displeased with the towability on cross-country routes and the ability to back up with the generator/trailer attached.

b. One driver gave "Inadequate" ratings for the overall size and weight of the trailer, and for the design features for mounting the trailer safely. One driver gave a "Very Inadequate" rating for the brakes. In general, the three drivers gave "Adequate" ratings for all other items relating to the design features of the trailer.

6.1.3.20.4 Comments Made By Three Drivers

a. One driver commented: The overall size and weight of the trailer is too big. Use the next smaller size.

b. One driver commented: The design features for mounting the trailer safely are inadequate. The walking surfaces are slippery when wet with a mixture of diesel and water.

c. One driver commented: The control panel should be mounted at the rear of the generator. This would eliminate the need for climbing upon the trailer and around the generator cables when trying to use the operator's control panel.

d. One driver commented: I thought the trailer was very good. At times, I had to look twice to see if the trailer was still on the truck. I think there should be something placed on the side of the trailer so the driver can see it more easily.

e. One driver commented: We experienced problems with the brakes locking up while the generator was being towed. The expedient solution in the field was to drain the air tank and turn off the air line.

6.1.3.20.5 Analysis

Analysis of the preceding results led to the identification of human factors problems and the classification of these problems into the following critical and non-critical categories:

a. Critical Problems

1. Problem: The fuel gauge is inadequately located inside the acoustical enclosure. The location is so far down in an unlighted area that it interferes with normal monitoring and refueling operations.

Violations of MIL-STD-1472C: Sections 4.4(f), 5.2.1.4.1, 5.2.1.4.2, and 5.9.4.5

Recommendation: The fuel gauge should be placed on the operator's control panel.

2. Problem: The lugs on the switch box are too close together, making the load terminals very inaccessible and hard to check. It is difficult to connect 3 or 4 large cables to the lugs--as the Army must do sometimes.

Violations of MIL-STD-1472C: Sections 4.4(f) and 5.9.4.5

Recommendation: Spread the lugs apart more, so that power connections are easier to make, are more accessible, and are easier to check.

3. Problem: The switch box is mounted at an angle on the trailer--this causes the box and the lugs to be tilted. It is difficult to hook-up the second generator to the switch box because you almost have to work upside down to get to the lugs. The configuration leads to time delays for completing the hook-up procedures and enhances the chances of causing damage to equipment and injury to personnel.

Violations of MIL-STD-1472C: Sections 4.4(f) and 4.4(m)

Recommendation: The switch box should be relocated to the trailer tongue area and should be mounted on a horizontal plane. (As recommended elsewhere, the operator's control panel should be moved from the trailer tongue area and relocated to the sides or rear of the generator.) Another way to simplify the hook-up procedures for the second generator would be to use a plug-in connector or a hock.

4. Problem: The wires inside the cables are color-coded, but the lugs on the generators are numbered or lettered. The manual does not tell which color to hook-up to which number.

Violation of MIL-STD-1472C: Section 5.5.1.1

Recommendation: The manual should be explicit about which colored wire goes to which terminal. Also, the manufacturer of this generator should make the label for a designated terminal consistent with the label for the corresponding terminal on a military standard generator. These changes would help clear up some of the confusion associated with hook-up procedures.

5. Problem: The power cable coming from the lug area obstructs the accessibility of the operator's control panel. An operator has to climb over the cable to get to the panel in the trailer tongue area.

Violations of MIL-STD-1472C: Sections 4.4(f) and 5.9.4.5

Recommendation: Redesign the generator/trailer so the trailer tongue area is not so congested, i.e., separate the control panel from the power cables so the panel will be more accessible to the operator. The following options would improve the situation: a) bring the power cables out the left side of the generator instead of the right side; b) redesign the panel door so that it opens from left to right instead of right to left; and c) move the operator's panel to the rear of the generator or to the side of the generator opposite the power cables. The latter option is the most preferred one.

6. Problem: The fuel fill is inadequately located inside the acoustical enclosure.

Violations of MIL-STD-1472C: Sections 4.4(f) and 5.9.4.5

Recommendation: The fuel fill should be placed outside the acoustical enclosure for ease of use and for safety purposes.

7. Problem: The water/coolant fill is inadequately located inside the acoustical enclosure. The radiator sits so high that it is difficult to check and service from inside the acoustical enclosure.

Violations of MIL-STD-1472C: Sections 4.4(f) and 5.9.4.5

Recommendation: The water/coolant fill should be placed on top of the acoustical box so the radiator can be checked and serviced externally.

8. Problem: The oil fill is inadequately located inside the acoustical enclosure. The operator must take two doors off to get to it. When he adds oil, he must contend with a bar in the same position as the oil fill. It is easy for the operator to bang his hands while servicing the engine with oil.

Violations of MIL-STD-1472C: Sections 4.4(f) and 5.9.4.5

Recommendation: The oil fill should be located outside the acoustical enclosure and separated spatially from the proposed, external fuel fill. An external dip stick or an oil level gauge on the operator's control panel should be added so the operator can determine when oil is needed. These changes would permit the operator to check and service the engine with oil from outside the acoustical enclosure.

9. Problem: The access doors are too difficult to open and close for normal maintenance and emergency purposes. They are too heavy to be lifted by female operators. The multiple-turn latches are slow to operate and unreliable as a means of closure.

Violations of MIL-STD-1472C: Sections 4.4(m), 5.9.9.2, 5.9.9.4.1(b), 5.9.10.2, and 5.9.12.9

Recommendation: The access doors should be self-supporting so they can be opened quickly and easily. They should be hinged on one side and latched on the other (with tongue-and-slot catches). The doors should have positive locks or braces to secure them when they are in the "opened" position.

10. Problem: The trailer is too large for the generator. Also, the hook-up mechanism on the trailer is not compatible with the size and weight of the generator/trailer. Hooking the heavy generator/trailer to a tow vehicle is a slow and difficult process. For instance, raising the landing-gear tires to the towing position is very time consuming. In addition, 3 or 4 people are needed to load and unload the generator/trailer onto a new vehicle.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: The size and weight of the generator should be made compatible with the size and weight of the trailer. The hook-up mechanism should be redesigned so that it facilitates setting up the generator and preparing it for transit. These changes would improve the mobility of the generator/trailer in tactical situations.

11. Problem: The fender walls on the trailer are located too close to the tires. You have to jack up the fender to pull off the tires. This requirement would severely degrade your mobility in a tactical situation.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: The fender walls on the trailer should be redesigned so that the tires may be changed more easily and quickly.

b. Non-Critical Problems

1. Problem: The operator's panel lights are not bright enough to effectively illuminate the control panel at night. An operator cannot see the top three gauges (i.e., the voltmeter, the ammeter, and the frequency meter) without his flashlight. Integral lights are not provided inside the gauges.

Violations of MIL-STD-1472C: Sections 4.4(h), 5.1.1.5, and 5.2.1.2.1.1

Recommendation: Use 3 or 4 external white lights on the operator's panel and low luminance, integral red lights for all gauges. The brightness of all lights should be adjustable and all lights should be extinguishable with on-off switches. This light configuration would allow maximum flexibility for operating during daytime, nighttime, and blackout conditions.

2. Problem: The alarm light does not give enough information, i.e., it does not differentiate between an oil problem and a water problem.

Violations of MIL-STD-1472C: Sections 5.2.1.3.1, 5.2.2.1.1, and 5.2.2.1.3

Recommendation: At least three alarm lights should be placed on the operator's control panel. These three should be labeled "Low Oil Level," "Low Water Level," and "Low Fuel Level."

3. Problem: The batteries are difficult to access for maintenance purposes. The operator has to open the access panels and stick his head into the hot housing area. If the fender skirts were wet, he could slip and fall into the engine.

Violations of MIL-STD-1472C: Sections 4.4(f) and 5.9.4.5

Recommendation: Create a separate compartment for the batteries and mount them side-by-side on a sliding tray. The compartment should allow the batteries to be serviced without having to open the access panels. The operator could slide the tray out to access each battery individually.

4. Problem: The workspaces in front of the operator's panel and on the sides of the generator are very inadequate. There is no platform or acceptable walking space in front of the operator's panel. The workspace on the side of the generator is obstructed by the presence of a junction box.

Violations of MIL-STD-1472C: Sections 4.4(d) and 4.4(i)

Recommendation: Move the operator's panel to the side or to the rear of the generator. Add a pull-down step to serve as a platform at the new location of the control panel. Move the junction box to the front of the generator (i.e., near the trailer tongue) so it will be near the power connections.

5. Problem: The amount of workspace within the acoustical enclosure is inadequate for servicing the generator with fuel, oil, and water.

Violation of MIL-STD-1472C: Section 4.4(d)

Recommendation: Relocate the fuel fill, the oil fill, and the water/coolant fill to the outside of the acoustical enclosure.

6. Problem: There is an inadequate amount of storage space on the generator/trailer.

Violations of MIL-STD-1472C: Sections 4.4(d) and 5.9.1.2

Recommendation: Increase the storage space to accommodate more fuel cans, fuel filters, oil cans, oil filters, special tools, grounding rods, and an operator's manual.

7. Problem: The operator's manual contained too much maintenance-related detail and too little operations-related detail. Most of the manual was too difficult to be understood by the typical generator operator. Two important things were missing from the manual: a PMCS table and an output wiring diagram describing the proper way to hook up the cables.

Violation of MIL-STD-1472C: Section 4.1

Recommendation: Rewrite the manual, keeping the needs of the operator in mind.

6.1.3.21 Manufacturer I, 30 kW, 60 Hz Generator

6.1.3.21.1 Ratings Made By Nine Operators

a. Environment. In general, the operators gave "Acceptable" ratings for the noise levels of the generator when the baffles and doors were closed and when they were open. The nine operators gave "Acceptable" ratings for the vibration level and temperature level near the generator during normal operations. In general, the operators gave "About right" ratings for the daytime and nighttime light levels at the operator's panel during normal conditions. However, two operators expressed dissatisfaction with the nighttime light levels at the operator's panel during blackout conditions.

b. Indicator Lights. In general, the operators gave "Adequate" and "Very Adequate" ratings for the indicator lights. However, one operator was dissatisfied with the brightness of the indicator lights at night and another operator was dissatisfied with the timeliness of information given by the indicator lights.

c. Gauges. In general, the operators gave "Adequate" and "Very Adequate" ratings for the gauges. However, two operators were dissatisfied with the timeliness of information given by the gauges and three operators were dissatisfied with the precision of information given.

d. Controls. In general, the operators gave "Adequate" and "Very Adequate" ratings for the controls. However, one operator was dissatisfied with the size, shape, and resistance of a control (i.e., the main circuit breaker).

e. Power Connections. In general, the operators gave "Adequate" and "Very Adequate" ratings for the power connections. However, two operators were displeased with the size of the lugs, the spacing between lugs, and the ease of connecting cables. One operator was displeased with the labels for lugs and the accessibility for making power connections.

f. Equipment Location. In general, the operators gave "Adequate" and "Very Adequate" ratings for the location of equipment. However, four operators were displeased with the configuration on the trailer and the location of the water/coolant fill. Three operators were displeased with the location of the fuel fill. Two operators were displeased with the location of the gauges and batteries.

g. Workspace and Storage Space. In general, the operators gave "Adequate" and "Very Inadequate" ratings for the workspace within the acoustical enclosure and the design features for mounting the generator/trailer to perform duties. The operators gave a wide range of ratings (from "Very Inadequate" to "Very Adequate" to "Not Applicable") for items relating to storage space for fuel cans, tools, spare parts, manuals, and grounding rod. These ratings are difficult to interpret due to their variability.

h. Operational Procedures. In general, the operators were satisfied with the generator's ease of operation during normal conditions. However, two operators gave "Difficult" ratings for transporting the generator. One operator gave "Difficult" ratings for locating the generator in place and setting up generator/preparing for start-up. Another operator gave "Difficult" ratings for camouflaging the generator.

i. Maintenance Procedures. In general, the operators were satisfied with the ease of performing maintenance on the generator. Three operators gave "Difficult" and "Very Difficult" ratings for checking the radiator. Two operators gave "Difficult" ratings for servicing the radiator.

j. Operator's Manual. Meaningful statements about the manual cannot be made since only 2 of the 9 operators used it in the field (and these two used it sparingly).

k. Tools. In general, the operators rated the normally-issued tools as being "Adequate" for performing PMCS and troubleshooting.

l. Trailer. There was a significant amount of dissatisfaction with the trailer. Four operators gave "Inadequate" and "Very Inadequate" ratings for the length of the trailer and the height of the chassis above ground. Three operators gave "Inadequate" and "Very Inadequate" ratings for the following items: Overall Size and Weight of Trailer, Width of Trailer, Tire Configuration of Each Side, Hook-up Mechanism, and Size of Lugs.

6.1.3.21.2 Comments Made By Nine Operators

a. Environment

1. One operator commented: It is hard to see some of the gauges on the operator's panel at night. The gauges with white backgrounds (i.e., the AC voltmeter, the ammeter, and the frequency meter) were easy to see, but the gauges with black backgrounds were hard to see.

2. One operator commented: The light configuration needed for nighttime use is the same as that found on mil std generators - i.e., 3 or 4 panel lights on the operator's control panel that can be turned on and off manually by flipping a switch. Such a configuration allows flexibility for normal nighttime operations as well as blackout nighttime operations.

3. One operator commented: When you take the doors off to work on the generator, it's pretty hot in there. There's just one ventilation opening. There should be more.

4. One operator commented: The ambient light for working on the engine compartment during daytime is very adequate. At nighttime it is hard to check the readings on the generator because the instrument panel is not lighted.

b. Indicator Lights. Two operators commented: The green "Generator On" light is too bright for blackout conditions. I could see it from 100 yards away. An operator's panel light would be helpful because you could turn it on and off.

c. Gauges

1. One operator commented: If you are going to have a digital frequency meter, why not have a digital ammeter and voltmeter as well? If anything is digital, it should be the latter two because if you are pulling too many amps you could blow the generator and if you are pulling too many volts you could blow one of the vans. A digital ammeter and digital voltmeter would allow for quicker readings.

2. One operator commented: Increments on gauges are very good and very accurate. I like the digital frequency meter because it's more precise than the regular gauges--more like the precision found on a 60K mil std generator.

3. One operator commented: The voltage gauge shows 220 volts, but should show 120. I am only using single phase 120 right now, but the gauge shows 208 volts.

4. One operator commented: The voltage gauge should be the right type.

5. One operator commented: The oil pressure gauge is inoperative.

6. One operator commented: The fuel gauge is in a good location.

d. Controls

1. One operator commented: The main circuit breaker is difficult to flip for a small person in an emergency situation. I had to push it several times before it flipped off.

2. One operator commented: The controls are easy to get to and easy to operate.

3. One operator commented: The directions for powering up the generator describe the two positions for the Main Circuit Breaker Switch as "open" and "closed," whereas the label on the switch reads "off" and "on." Someone needs to standardize the language used to avoid confusion.

4. One operator commented: The directions for powering up the generator are out of order--i.e., Step 1 and Step 3 should be reversed.

e. Power Connections

1. Four operators commented: The lug terminals are too small. You can only put 1 cable in there comfortably, and we normally hook up 4 or 5 cables to each terminal. Therefore, it is hard to get into the terminal area. I had to pull the nuts all the way off and tap the cables in there. The ground lugs are too small for military use also.

2. One operator commented: We normally use a hock to hook up power cables, rather than hooking the wires up directly to the lugs.

3. One operator commented: The grounding strap is too small.

4. One operator commented: The cover over the lugs should be redesigned.

f. Equipment Location

1. Two operators commented: It is very difficult to check and fill the radiator because of the location of the water/coolant fill. It is right underneath the baffling in the top rear. With the rain plates in there, the radiator is hard to check, and real hard to fill up. They should put the radiator neck on top of the acoustical box, or raise it above the rain plates.

2. Two operators commented: The radiator is difficult to get to. You have to stop the generator to check and fill the radiator. You can't put water in it unless you have a canteen.

3. One operator commented: One should be able to check the coolant, or add coolant, without having to get into the housing.

4. One operator commented: The batteries are impossible. They're mounted one on top of the other, so they're hard to get to, hard to service, and hard to change. I like the little boxes they're mounted in though.

5. One operator commented: The battery box has a strap on it. If it had clip-ons, you could get to it a lot faster.

6. One operator commented: I should be able to check oil while the generator is running, like on mil std 60 KW generators.

7. One operator commented: There are no storage compartments on the trailer or inside the generator. We need them.

8. One operator commented: The fuel fill is too small. We had to use a funnel to fill from a tank in the motor pool, but the nozzle on the tanker in the field worked O.K. A larger fuel fill would be more versatile and would reduce spillage.

9. One operator commented: The way the side doors are set up, everything is easily accessible on the generator. However, the doors should have better latches. The latches are bad because they don't close sometimes. To get the latches to work properly, you have to screw them all the way out,

then you have to screw them all the way down so they're tight. If they'd just put simple latches on the doors like on mil std generators, the doors would work just fine.

10. One operator commented: Having the air intake and exhaust doors on top of the generator is a bad design for the Army's use. In the field, we have to put camouflage nets over the top of generators. Since the top doors on this generator stick straight up, it gets really hot under the camouflage net and the exhaust is liable to burn a hole in the net. I suggest that the manufacturer of this generator move the 2 top doors to the front, the back, or the sides of the generator.

g. Workspace and Storage Space

1. One operator commented: In order to get on top of the generator to check and fill the radiator, you have to get a boost from someone else. Some footholds or rungs on the side of the generator would be helpful for getting on top of the generator.

2. Three operators commented: There is no room to store anything. For safety reasons you don't want to store anything next to the engine or the generator because you don't want anything to get caught up in either one. But, there is no storage space on the trailer either. The trailer needs an accessories box for the tools, spare parts, ground rods, manuals, etc. --(like on mil std 30 KW and 60 KW generators).

3. One operator commented: Any storage box needs to have a lock on it so you can prevent pilferage.

4. One operator commented: The storage box at the front of the generator was only large enough for the chock blocks (which were too small for the generator). The box needs to be larger so you can store grounding rods, etc.

h. Operational Procedures

1. One operator commented: You have to be extremely careful when transporting the generator not to drive over any large rocks or stumps because the trailer sits too low.

2. One operator commented: The trailer is too narrow so you can't see what you are pulling. When you back up, it jack knifes too easily. The trailer needs to be higher off the ground.

3. One operator commented: The doors are a pain to open and close.

4. One operator commented: Everything is readily accessible on this generator. It's easier to hook up a load connection on this generator than it is on a mil std 15 KW, 30 KW, or 60 KW.

5. One operator commented: This generator is hard to camouflage due to its size and to our not being allowed to put camouflage nets over the top doors which must remain open.

i. Maintenance Procedures

1. One operator commented: Checking batteries is very difficult because they're hard to get to. They are placed one on top of the other, so you have to take the top battery out to get to the bottom battery. The operator may not check and service the batteries because it's just too hard to do.

2. Two operators commented: The radiator is too hard to get to, so checking and servicing the radiator is a pain. One should be able to check and add coolant without having to get into the housing.

3. One operator commented: The engine oil dipstick should have a dual indicator capability (like the mil std 60 KW) so you can check the oil level when the generator is idle or when it is running.

j. Operator's Manual. One operator commented: The manual pretty well covered operator maintenance, but wasn't very descriptive for troubleshooting and performing organizational maintenance. It really didn't cover anything but operator maintenance.

k. Tools. One operator commented: We could use a lug terminal wrench. It should be a fiberglass model so you won't strip the lugs.

1. Trailer

1. Five operators commented: The trailer is not made for tactical situations. It is too long, too narrow, and too low to the ground; consequently, it is hard to make turns and to transport over rough terrain. The chassis sits less than 2 feet off the ground. This is not enough for moving around in the brush or over rough terrain. The fender skirts are flimsy and will come off the first time they hit a tree. The trailer has only one leg in front and it doesn't look too sturdy either. The dual axle is a good idea.

2. One operator commented: The trailer needs bigger tires to raise the chassis off the ground a bit more and increase the generator's mobility.

3. One operator commented: The fuel tank is mounted in the trailer which is a good idea, but the fuel tank is a little bit too wide. The extra width allows more condensation to form in the top of the fuel tank--causing more water to get into the fuel system.

4. Two operators commented: The fuel tank is in the wrong place. It is too low to the ground which makes it too easy to puncture.

5. One operator commented: One generator had a distribution box on the front of the trailer. It had only 1 hook going into the box whereas we have to have a back-up at all times so we can changeover in case 1 generator goes down. It was very difficult to rig up the power box to fit our needs. We had to take the box with 1 hook and wire another camel into that box to hook into another distribution box so we could have a back-up at all times. That distribution box doesn't work at all--it's not adequate for our needs. We need one with a double hook on it so we can have a back-up at all times.

6. One operator commented: The trailer itself is inadequate. It sits too low and the tires are too small. The generator drags across bumps when you go cross-country. It does not pull very well either. With the trailer being so low, the tongue drags when you go into a ditch and the tail drags when you come out. If it were higher off the ground, it would be a lot better. Also, if the trailer had side-by-side dual wheels (instead of tandem wheels), it could go through a ditch easier.

7. Two operators commented: The brakes on the trailer tended to lock up, so we didn't use them.

8. One operator commented: There is too much space in the tongue region of the trailer.

6.1.3.21.3 Comments Made By Six Drivers

a. The six drivers gave "Easy" and "Very Easy" ratings for the towability of the generator/trailer on straight, paved, and gravel roads at speeds below 25 mph and above 25 mph. One operator gave a "Difficult" rating for the towability around curves on paved and gravel roads. Two operators gave "Difficult" ratings for the towability on cross-country routes. Five operators gave "Easy" ratings for the ability to back up with the generator/trailer attached.

b. There was a great deal of variability in drivers' ratings for the design features of the generator/trailer. In general, the drivers rated these features as "Adequate" and "Very Adequate." Three drivers gave "Inadequate" or "Very Inadequate" ratings for the height of chassis above ground and the brakes. Two drivers gave "Inadequate" ratings for the tire configuration on each side and the tire size.

6.1.3.21.4 Comments Made By Six Drivers

a. One driver commented: The trailer sits too low for cross-country travel.

b. One driver commented: The design of the trailer makes it easy to jackknife.

c. One driver commented: The trailer has no handbrakes, and it should have them.

d. One driver commented: The safety chain hooks are too small to hook up adequately.

e. One driver commented: The trailer is so long that it makes taking curves difficult since the trailer takes a sharper corner than does the tow vehicle, a 2 1/2-ton truck.

f. One driver commented: It takes too many turns on the crank to get the leg of the jack up and down.

6.1.3.21.5 Analysis

Analysis of the preceding results led to the identification of human factors problems and the classification of these problems into the following critical and non-critical categories:

a. Critical Problems

1. Problem: The lug terminals are too small and too close together. Sometimes the Army needs to hook 4 or 5 large cables to each terminal, and this is difficult to do in the cramped terminal area provided on this generator.

Violations of MIL-STD 1472C: Sections 4.4(f) and 5.9.4.5

Recommendation: Increase the size of the lugs and spread them apart more--so that power connections are easier to make, are more accessible, and are easier to check.

2. Problem: The cover over the terminal area is very inadequate. It must be held manually in the "up" position while power connections are being made. After the connections are made, the plexiglass cover rests on the cables, providing little protection from accidental electrical shock. [The plexiglass cover was fabricated specifically for this test--to replace an even more unacceptable, cloth-type cover.]

Violations of MIL-STD-1472C: Sections 4.4(f) and 4.4(c)

Recommendation: Replace the present cover with one which is easy to use and provides an adequate safeguard against accidental electrical shock.

3. Problem: The engine must be shut down to service it with water/coolant.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: Redesign the coolant system so that water/coolant may be checked and replenished while the engine is running.

4. Problem: The engine must be shut down to service it with oil.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: Redesign the lubrication system so that oil may be checked and replenished while the engine is running.

5. Problem: The access doors are too difficult to open and close for normal maintenance and emergency purposes. The multiple-turn latches are slow to operate and unreliable as a means of closure.

Violations of MIL-STD-1472C: Sections 4.4(m), 5.9.9.2, 5.9.9.4.1(b), 5.9.10.2, and 5.9.12.9

Recommendation: The access doors should be self-supporting so they can be opened quickly and easily. They should be hinged on one side and latched on the other (with tongue-and-slot catches). The doors should have positive locks or braces to secure them when they are in the "opened" position.

6. Problem: The air intake and exhaust doors are close together on top of the generators. This is a poor design for two major reasons: a) the top doors stick straight up--interfering with the camouflaging of the generator and creating a fire hazard involving the camouflage net and the hot exhaust, and b) the top doors for air intake and exhaust are so close together that air intake may be contaminated with air exhaust.

Violations of MIL-STD-1472C: Sections 4.4(c), 4.4(f), and 5.8.1.2

Recommendation: Move the air intake and exhaust doors from the top of the acoustical enclosure and separate them from each other. Possible locations include the front, back, and sides of the generator.

7. Problem: The trailer is too long, too narrow, and too low to the ground. The tires are too small. Consequently, it is hard to make turns and to transport the generator over rough terrain. The fender skirts are too flimsy and will come off the first time the generator/trailer hits a tree. The trailer has only one leg in front and it is not very sturdy.

Violation of MIL-STD-1472C: Section 4.9

Recommendation: The trailer should be shortened, widened, and raised off the ground some more. Commensurate modifications to the size of the generator should be implemented. The trailer needs bigger tires to raise the chassis off the ground some more. This would increase the generator's mobility during tactical situations. Consideration should be given to using side-by-side dual wheels on each side, instead of the present tandem wheels. The side-by-side tire configuration would help the generator/trailer get across ditches better.

8. Problem: The brake system for the generator/trailer is inadequate. The air brakes have a tendency to lock up. There is no hand brake on the generator/trailer; chock blocks must be used to stabilize the generator.

Violation of MIL-STD-1472C: Section 4.9

Recommendation: The air brake system should be improved and a hand brake should be added.

9. Problem: The labeling scheme for the load terminals is different from the labeling scheme used for military standard generators.

Violation of MIL-STD-1472C: Section 5.5.1.1

Recommendation: Make the label for a designated terminal on this generator consistent with the label for the corresponding terminal on military standard generators.

b. Non-Critical Problems

1. Problem: The light configuration on the operator's control panel is inadequate. There are no panel lights and the green "Generator On" light is too bright for blackout conditions. In addition, the gauges that have black backgrounds are difficult to see at night. Those gauges with white backgrounds (i.e., the AC voltmeter, the ammeter, and the frequency meter) are easy to see.

Violations of MIL-STD-1472C: Sections 5.1.1.5 and 5.2.1.2.1.1

Recommendation: Use 3 or 4 external white lights on the operator's panel and low luminance, integral red lights for all gauges. Use white backgrounds with black markings for the gauges. The brightness of all lights should be adjustable and all lights should be extinguishable with on-off switches. This light configuration would allow maximum flexibility for operating during daytime, nighttime, and blackout conditions.

2. Problem: The acoustical enclosure does not have adequate ventilation. There is only one ventilation opening, so the air gets pretty hot within the acoustical enclosure and the gases/fumes are not properly ventilated.

Violations of MIL-STD-1472C: Sections 4.4(c) and 5.8.1.2

Recommendation: Add another ventilation opening to the acoustical enclosure of the generator.

3. Problem: The precision of information obtained from the voltmeter, ammeter, and frequency meter varies considerably since dial readings are made for the voltmeter and ammeter, and digital readings are made for the frequency meter.

Violations of MIL-STD-1472C: Sections 5.2.1.3.2 and 5.2.1.3.3

Recommendation: Change the voltmeter and ammeter so that they give digital readings like the frequency meter does. This would allow quick and precise readings to be taken from all three gauges.

4. Problem: The directions for providing power from the generator describe the two positions for the main power switch as "open" and "closed", whereas the label on the switch reads "off" and "on".

Violation of MIL-STD-1472C: Section 5.5.6.2.3(c)

Recommendation: Change the directions for providing power from the generator. Describe the two positions for the main power switch as "off" and "on". This will make the directions specify the functional result of tripping the main power switch and make the directions consistent with the labeling of the switch.

5. Problem: The water/coolant fill is located near the top rear of the generator beneath the baffling for the air intake and exhaust. There are no handholds or footholds to be used for mounting the generator. Thus, it is not designed for maintainability.

Violations of MIL-STD-1472C: Sections 4.4(f) and 5.9.4.5

Recommendation: Relocate the water/coolant fill so that the radiator neck is directly on top of the acoustical enclosure but away from the air intake/exhaust area. Place handholds and footholds on sides of the generator.

6. Problem: The batteries are difficult to access for maintenance purposes. One battery is stored directly underneath the other battery. You have to remove the top one to get to the bottom one.

Violations of MIL-STD-1472C: Sections 4.4(f) and 5.9.4.5

Recommendation: Create a separate compartment for the batteries so they can be mounted side-by-side. The compartment should allow the batteries to slide in and out easily so they can be accessed individually without difficulty.

7. Problem: The storage space on the generator/trailer is too small. The chock blocks may be stored, but the generator/trailer can store few other items for maintainability of generator.

Violation of MIL-STD-1472C: Section 5.9.1.2

Recommendation: Storage space should be provided for special tools, spare parts, fire extinguishers, grounding rods, fuel, oil, water and other maintainability items. This space should be provided with a lock so that pilferage may be prevented.

8. Problem: The fuel fill is too small. It is hard to use and contributes to the large amount of fuel spillage associated with this generator.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: Increase the size of the fuel fill. A larger one would be more versatile since it would be able to receive fuel from various-sized nozzles. A larger one would also help reduce spillage for this generator.

9. Problem: The jack stand on the trailer tongue is inadequate. It takes too many turns on the crank to get the leg of the jack up and down.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: Replace the current jack stand with one that operates more efficiently.

6.1.3.22 Manufacturer A, 60 kW, 400 Hz Generator

6.1.3.22.1 Ratings Made By Four Operators

a. Environment. The four operators gave "Acceptable" ratings for the noise levels of the generator when the baffles and doors were closed and when they were open. Three operators rated the vibration level of the generator as "Somewhat too high." The four operators gave "Acceptable" ratings for the temperature level near the generator during normal operation. The four operators gave "About right" ratings for the daytime and nighttime light levels at the operator's panel during normal conditions. The four operators gave "About right" ratings for the nighttime light levels achieved by red lens flashlights during nighttime, blackout conditions.

b. Indicator Lights. Three operators gave "Adequate" and "Very Adequate" ratings for the indicator lights.

c. Gauges. Three operators gave "Adequate" and "Very Adequate" ratings for the gauges.

d. Controls. Three operators gave "Adequate" and "Very Adequate" ratings for the controls.

e. Power Connections. Three operators gave "Adequate" ratings for the labeling of lugs. Three operators gave "Very Inadequate" ratings for the size of lugs, spacing between lugs, accessibility, and ease of connecting cables.

f. Equipment Location. Three operators gave "Adequate" and "Very Adequate" ratings for the location of the following items: Operator's control panel, Indicator lights, Gauges, Start-Stop switch, Battle Short switch, Batteries, and Fuel selector switch. Three operators gave "Not Applicable" ratings for the location of the choke control and storage compartments. Three operators gave "Inadequate" and "Very Inadequate" ratings for the location of the following items: Governor control, Fuel fill, Oil fill, and Water/Coolant fill. Three operators were also displeased with the configuration on the trailer.

g. Workspace and Storage Space. Three operators gave "Adequate" and "Very Adequate" ratings for the amount of workspace within acoustical enclosure and the amount of workspace outside the acoustical enclosure--i.e., the design features for mounting generator/trailer to perform duties. Three operators gave "Not Applicable" ratings for the amount of storage space for fuel cans, tools, and spare parts. Three operators gave "Very Inadequate" ratings for the amount of storage space provided for grounding rods and camouflage nets.

h. Operational Procedures. Three operators gave "Easy" and "Very Easy" ratings for all items relating to operational procedures, except "Start up generator manually" (which was not applicable) and "Switch power output from one generator to the other in a pair of generators." Four operators rated the latter item as "Did Not Perform" because no paralleling box or power distribution box was provided during the exercise.

i. Maintenance Procedures. Three operators gave "Easy" and "Very Easy" ratings for the following items: Perform overall check of generator system, Check instruments for normal operation, Replace lamps and fuses, Check batteries, Service batteries, Check engine oil, and Check for fuel leaks. Three operators gave "Difficult" and "Very Difficult" ratings for checking the radiator, servicing the radiator, and refueling the generator. No operator performed unscheduled maintenance actions.

j. Operator's Manual. An operator's manual was not present with this generator, so no ratings were given.

k. Tools. No ratings were given for the adequacy of normally-issued tools.

l. Trailer. Three operators gave "Adequate" and "Very Adequate" ratings for the following items: Length of trailer, Width of trailer, Sturdiness of trailer, Tire configuration on each side, Tire size, Hook-up mechanism, Brakes, and Design features for mounting trailer safely. Three operators gave "Not Applicable" ratings to all items relating to power box--apparently no power box was provided for the exercise. One operator gave "Inadequate" and "Very Inadequate" ratings to the following items: Overall Size and Weight of Trailer, Height of chassis above ground, Fuel storage, and Brakes.

6.1.3.22.2 Comments Made By Four Operators

a. Environment. No comments were made relating to this section.

b. Indicator Lights. One operator commented: On one occasion, the generator's Overtemp Light came on. The generator did not shut down (which was good).

c. Gauges. No comments were made relating to this section.

d. Controls. No comments were made relating to this section.

e. Power Connections

1. Three operators commented: The lugs were too big to handle the size of cables we have.

2. One operator commented: The lugs were too close together, so it was very difficult to connect our cables.

3. Four operators commented: We needed a power distribution box in order to perform our tactical mission. We were promised one, but never received it for the exercise.

4. One operator commented: The power connections did not suit our needs in general.

5. One operator commented: The load terminals were very inaccessible and hard to check.

f. Equipment Location. One operator commented: The radiator caps are hard to get to.

g. Workspace and Storage Space. Three operators commented: The amount of storage space for camouflage gear is very inadequate.

h. Operational Procedures

1. Four operators commented: Paralleling cables and power distribution boxes were not provided for the exercise, so we had to change the cables out everytime we wanted to switch from one generator to another one. This amounted to a lot of extra work and caused a lot of downtime. And, downtime defeats our mission.

2. One operator commented: This generator is hard to test without a power distribution box, because our power requirements are located here, over there, and all over the place.

3. One operator commented: A power distribution box for the generator would allow for easier attaching of load cables.

i. Maintenance Procedures

1. One operator commented: There is no problem in this area. The generator has been running straight for six days.

2. One operator commented: You could not service the radiator while the engine was running. For easier servicing, I recommend a setup that is similar to that on a car--where all you have to do is service a jug and the radiator draws in the water itself.

3. Three operators commented: Refueling was difficult because of the angle of the filler neck. Refueling was a very slow process and hard to do without spillage.

4. One operator commented: The load terminals are very inaccessible and hard to check.

5. One operator commented: The radiator needs a pressure relief cap for checking coolant.

6. One operator commented: You could not service the engine with oil without shutting the unit down.

j. Operator's Manual. An operator's manual was not present with this generator, so comments were not obtained.

k. Tools. No comments were made relating to this section.

l. Trailer

1. Two operators commented: The generator/trailer configuration does not benefit our tactical operations. If we used this type of generator (i.e., one generator permanently attached to a trailer), we'd probably need 8 or 10 of them out here. There is no way we could pull all of them out, along with our other equipment too. We have to have our generators skid-mounted. If two of these generators were put on one pallet and a power distribution box were put in the middle, this would suit our needs perfectly. For our mission to succeed, we cannot allow a power outage. For the test, we could not parallel the generators, so we had to shut down to check oil and service them.

2. One operator commented: I didn't like the tow bar going one way and the brackets going the other way.

3. One operator commented: The trailer itself was too bulky for our needs. In one specific case, the tongue of the trailer snapped off.

4. One operator commented: The brake lines are located in the wrong position. They are being dented and cut whenever the tongue is in the "up" position. In one case, we broke the brake lines. Suggestion: Reroute the brake lines over the top of the outside tongue.

6.1.3.22.3 Ratings Made By Six Drivers

a. In general, the drivers were satisfied with the towability of the generator under various conditions. Six drivers gave "Easy" and "Very Easy" ratings for the towability of the generator/trailer on paved roads at speeds below and exceeding 25 mph and on gravel roads at speeds below 25 mph. Six drivers gave "Easy" and "Very Easy" ratings for the towability around curves on paved roads. Five drivers gave "Easy" and "Very Easy" ratings for the towability around curves on gravel roads. Four drivers gave "Easy" ratings for the towability across cross-country routes and for backing up with the generator/trailer attached.

b. In general, the drivers were satisfied with the design features of the trailer. Six drivers gave "Adequate" and "Very Adequate" ratings for the length of the trailer, the tire configuration on each side, and the tire size. Five drivers gave "Adequate" and "Very Adequate" ratings for the width of the trailer, height of chassis above ground, brakes, and design features for mounting trailer safely. Four drivers gave "Adequate" and "Very Adequate" ratings for Overall Size and Weight of Trailer and Hook-up mechanism. The items revealing the greatest amount of dissatisfaction were "Overall Size and Weight of Trailer" and "Hook-up mechanism." Two drivers gave "Inadequate" and "Very Inadequate" ratings for these two items.

6.1.3.22.4 Comments Made By Six Drivers

a. Two drivers commented: The trailer was good although at times through rough terrain it proved to be very heavy. It was also hard to pull uphill and cross-country.

b. One driver commented: The mounting system could be better. When we folded the leg up, we had a difficult time securing it because the mounts were bent.

c. Two drivers commented: The landing gear should be improved. We had one break in the field so we had to use jacks to support the weight of the generator.

d. One driver commented: The pins that secure the jack stand were missing.

e. One driver commented: The latches on the panel doors are inadequate and don't secure the doors for transport across country.

f. One driver commented: The tow bar and brace were set up in a poor configuration. The pin is hard to install and you hit the brake lines when the trailer tongue is in the "up" position.

6.1.3.22.5 Analysis

Analysis of the preceding results led to the identification of human factors problems and the classification of these problems into the following critical and non-critical categories:

a. Critical Problems

1. Problem: The noise levels with access doors closed and with them open are too high for tactical operations -- i.e., dB(A) at the operator's panel with door open is 95.

Violation of MIL-STD-1472C: Section 5.8.3.1

Recommendation: Before further consideration is given to this generator, the Army should retrofit it with a better acoustical package.

2. Problem: The vibration level of the generator is too high.

Violations of MIL-STD-1472C: Sections 4.4(b), 5.8.4.1, and 5.8.4.2

Recommendation: Redesign the generator to make it more stable while in operation.

3. Problem: The lugs are too close together, making the load terminals very inaccessible and hard to check.

Violations of MIL-STD-1472C: Sections 4.4(f) and 5.9.4.5

Recommendation: Spread the lugs apart more -- so that power connections are easier to make, are more accessible, and are easier to check.

4. Problem: The angle of the fuel fill makes refueling a difficult, time-consuming process which is hard to do without spillage.

Violations of MIL-STD-1472C: Sections 4.4(f) and 4.4(m)

Recommendation: The fuel fill should be angled more to ensure the rapidity, safety, ease, and economy of refueling operations and maintenance.

5. Problem: The engine must be shut down to service it with oil.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: Redesign the lubrication system so that oil may be checked and replenished while the engine is running.

6. Problem: The engine must be shut down to service it with water/coolant.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: Redesign the coolant system so that water/coolant may be checked and replenished while the engine is running. Add a pressure relief cap to the radiator.

b. Non-critical Problems

1. Problem: The generator/trailer is too heavy and too bulky. It is difficult to tow the generator/trailer uphill and cross-country.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: The generator/trailer should be streamlined for ease and safety of transport.

2. Problem: The landing gear is too flimsy to support the weight of the generator/trailer.

Violation of MIL-STD-1472C: Section 4.9

Recommendation: Redesign the landing gear so that it is sturdier.

3. Problem: The tow bar and brace are set up in a poor configuration. The pin is hard to install and you hit the brake lines when the trailer tongue is in the "up" position.

Violation of MIL-STD-1472C: Section 4.4(f)

Recommendation: Improve the towing, landing gear, and brake systems on the trailer.

6.1.3.23 Manufacturer H, 60 kW, 60 Hz Generator

6.1.3.23.1 Ratings Made By Two Operators

a. Environment. Both operators gave "Somewhat too high" ratings for the noise levels of the generator when the baffles and doors were closed and "Much too high" ratings when the baffles and doors were open. Both operators gave "Acceptable" ratings for the vibration level and temperature level near the generator during normal operational conditions. Both operators gave "About right" ratings to daytime light levels at the operator's panel during normal conditions. One operator gave an "About right" rating and the other one gave a "Somewhat too low" rating for the nighttime light levels at the operator's panel during normal conditions. Both operators gave "About right" ratings for the nighttime light levels at the operator's panel during blackout conditions.

b. Indicator Lights. Both operators gave "Adequate" ratings for the location of indicator lights and the labeling of indicator lights. One operator gave "Inadequate" ratings for the amount of information given by indicator lights and the relevance of this information.

c. Gauges. Both operators gave "Adequate" ratings for the brightness of the gauges during daylight, the labeling of the gauges, and the precision of information given by gauges. One operator gave a "Very Inadequate" rating to the location of the fuel gauge.

d. Controls. Both operators gave "Adequate" ratings for the type, size, and shape of controls. One operator gave an "Inadequate" rating for the resistance of a control--it was too hard to move. One operator gave an "Inadequate" rating for accessibility of the controls.

e. Power Connections. Both operators gave "Adequate" ratings for the labeling of lugs and the size of lugs. One operator gave an "Inadequate" rating for the ease of connecting cables.

f. Equipment Location. Both operators gave "Adequate" and "Very Adequate" ratings for the location of indicator lights, Start-Stop switch, governor control, choke control, batteries, storage compartments, and oil fill. Both operators gave "Inadequate" and "Very Inadequate" ratings for the configuration on trailer and the location of the fuel fill. One operator gave a "Very Inadequate" rating to the location of the water/coolant fill.

g. Workspace and Storage Space. Both operators gave "Adequate" ratings for the amount of workspace within the acoustical enclosure and the amount of storage space provided for fuel cans. One operator gave "Inadequate" ratings for the design features for mounting the generator/trailer to perform duties and the amount of storage space for grounding rods.

h. Operational Procedures. Both operators gave "Easy" and "Very Easy" ratings for starting up generator electrically, stopping generator normally, preparing generator for transit, and transporting generator. No "Difficult" or "Very Difficult" rating was given for any operational procedure performed during normal operations.

i. Maintenance Procedures. Both operators gave "Easy" ratings for checking ground terminal connection, checking instruments for normal operation, checking engine oil, and changing engine oil. One operator gave "Difficult" ratings for checking radiator and refueling generator.

j. Operator's Manual. Both operators stated that a manual was present with the generator and both stated that they used it between 1-5 times. Both operators gave "Adequate" ratings for the manual's description of the operator's control panel, the description of power connections, the description of cables, and the explanation of how to perform PMCS. One operator rated the manual overall as "inaccurate", "incomplete", and "ineffective." The other operator checked the "Don't Know" response for the overall ratings concerned with Accuracy, Comprehensiveness, and Effectiveness. Generalizations about the manual should not be made--due to lack of sufficient data.

k. Tools. The two operators gave different ratings for the adequacy of normally-issued tools. Generalizations about the tools should not be made--due to lack of sufficient data.

l. Trailer. One operator gave "Inadequate" ratings for the overall size and weight of trailer and fuel storage; "Very Inadequate" ratings for the length of trailer, tire size, and design features for mounting trailer safely; and "Adequate" and "Very Adequate" ratings for all other items. The other operator gave an "Adequate" rating for the brakes; an "Inadequate" rating for the length of trailer, and "Neither Inadequate Nor Adequate" for all other items.

6.1.3.23.2 Comments Made By Two Operators

a. Environment

1. Both operators commented: The noise level of this generator under load is still quite high, even with all the covers on. It is especially noisy under heavy loads and is noisier than the other generators I've heard.

2. One operator commented: The nighttime light levels around the operator's panel are inadequate for use of the panel. I had to use a flashlight or my lighter to read the gauges at night. Brighter bulbs are needed on the panel.

3. One operator commented: If I didn't have a flashlight at night, I couldn't see anything on the operator's panel. No lights are needed for daytime use.

b. Indicator Lights. No comments were made about the indicator lights.

c. Gauges

1. Both operators commented: The fuel gauge should be on the front panel.

2. One operator commented: The fuel gauge is inadequately located down inside the engine compartment. You cannot see it without a flashlight, even during the daytime.

d. Controls. One operator commented: There is no battle short switch. In a tactical situation, I may need something like that.

e. Power Connections

1. One operator commented: To connect the power cables to the generator you have to remove the panel under the operator's panel and run the cable through the side. This is a two-man operation.

2. One operator commented: We had to hook up so many cables to the switch box that we had to make it unsafe by taking off the protective cover.

f. Equipment Location

1. Both operators commented: The location of the fuel gauge is inadequate. This gauge should be located on the operator's panel.

2. One operator commented: There was no fuel selector switch, so we could not run off an auxiliary fuel supply like a 55-gallon drum.

3. One operator commented: The back of the generator needs a bumper on it because it hangs over the back of the trailer and could be damaged if you backed into something.

4. One operator commented: It is kind of hard to get to the water/coolant fill.

g. Workspace and Storage Space

1. One operator commented: There is no platform or acceptable walking space in front of the operator's panel. The front of the trailer is a safety hazard. We had one person fall through where the A-frame is. You have to get on the frame to check the operator's panel, but when you open the door you have to step back or lean back—and there is no place to stand. The small area immediately in front of the panel is too close to the panel, so you have to stand on the frame behind it.

2. One operator commented: There were only two fuel cans with the generator. That is definitely not enough for this size of generator. If something happens to the fuel truck, I am not going to run very long with just two cans of fuel.

3. One operator commented: You need storage space for grounding rods and a manual on the generator itself.

4. One operator commented: A place could be made to store the manual inside the door of the operator's panel.

h. Operational Procedures. No comments were made about operational procedures.

i. Maintenance Procedures

1. One operator commented: Generator was easy enough to operate. I just had trouble with the fuel indicator location, especially in blackout conditions.

2. One operator commented: The fuel inlet fills much too slowly. The fuel will come back out and spray everywhere if you try to fill the generator too fast.

3. One operator commented: It is difficult to perform operator maintenance with MOPP clothing on. With your protective boots restricting your mobility and your mask restricting your vision, you have to walk around the wires near the instrument panel--where there is no step or platform. With your rubber gloves and mask on, it is hard to control how much fuel you put into the tank during refueling operations.

j. Operator's Manual

1. One operator commented: The Table of Contents and Index were inadequate. They need to specify things in more detail. Some operators, who may not know as much about the generator, may need more detailed information on how to locate things like the fuel gauge.

2. One operator commented: I couldn't find anything in the Index about the oil filter, even though the Table of Contents referred to it.

3. One operator commented: I did not need the manual that much. We were schooled enough.

k. Tools. One operator commented: We needed a torque-drive screwdriver to take the front panel off so we could connect the power cable to the lugs.

l. Trailer

1. One operator commented: You almost have to take the fender off to change the tires.

2. One operator commented: You have to jack the fender up to pull the wheels off. It is the same type of trailer as the old mil std type, so I know for a fact that when you go to pull the tires off with a wheel puller, the fender wall gets in the way. All they have to do is take a 2-inch piece of metal off of the fender to solve the problem. I didn't have to change a tire out there on the exercise, but I know this from past experience with these trailers.

3. One operator commented: The trailer was not long enough for the generator. The acoustical box stuck out from the back of the trailer.

4. One operator commented: Two fuel cans are not enough. Six would be better.

5. One operator commented: It is difficult and a slow process to hook the generator/trailer to a tow vehicle. You need 3 or 4 people to load and unload it. On other types of trailers, you could do it by yourself if you had to. On this type trailer (with its small front wheel), you need more people.

6.1.3.23.3 Ratings Made By Two Drivers

a. Both drivers gave "Easy" ratings for the towability of the generator/trailer on paved roads at speeds exceeding 25 mph and the towability on gravel roads at speeds equal to or below 25 mph. Both drivers gave "Difficult" ratings for backing up with the generator/trailer attached.

b. Both drivers gave "Inadequate" ratings for the length of the trailer. Both drivers gave "Adequate" ratings for the tire configuration on each side, tire size, and brakes. One driver gave "Inadequate" ratings for the overall size and weight of trailer, hook-up mechanism, and design features for mounting trailer safely.

6.1.3.23.4 Comments Made By Two Drivers

a. One driver commented: The generator was sitting too high up on the trailer which made the generator/trailer configuration too top heavy. It might tip over when hitting a rut.

b. Two drivers commented: The generator was too long for the trailer. The acoustical box sticks out from the trailer at the rear, so there is no protection for the generator if someone hits you from the rear or you back into something. Suggestion: Redesign the generator/trailer configuration by putting a rear bumper on the acoustical box, making the generator shorter, or making the trailer longer.

c. One driver commented: The hook-up design on this generator does not allow a fast hook-up and sometimes a fast hook-up will be required in tactical situations.

d. One driver commented: When backing up the trailer out in the field, you have to be careful because the generator/trailer is bulky and there is no protection on the back of the generator if someone hits you or you hit something.

6.1.3.23.5 Analysis

Analysis of the preceding results led to the identification of human factors problems and the classification of these problems into the following critical and non-critical categories:

a. Critical Problems

1. Problem: The noise level near the operator's panel is too high for tactical operations, i.e., dB(A) at one foot from the opened panel door is 89.

Violation of MIL-STD-1472C: Section 5.8.3.1

Recommendation: Before further consideration is given to this generator, the manufacturer should retrofit it with a better acoustical package. Special attention should be given to the noise level around the operator's control panel and noise levels experienced under heavy loads.

2. Problem: The fuel gauge is inadequately located inside the acoustical enclosure. The location is so far down in an unlighted area that it interferes with normal monitoring processes and refueling operations.

Violations of MIL-STD-1472C: Sections 4.4(f), 5.2.1.4.1, 5.2.1.4.2, and 5.9.4.5

Recommendation: The fuel gauge should be placed on the operator's control panel.

3. Problem: The fuel fill is inadequately located inside the acoustical enclosure.

Violations of MIL-STD-1472C: Sections 4.4(f) and 5.9.4.5

Recommendation: The fuel fill should be placed outside the acoustical enclosure for ease of use and for safety purposes.

4. Problem: The water/coolant fill is inadequately located inside the acoustical enclosure. The radiator sits so high that it is difficult to check and service it from inside the acoustical enclosure.

Violations of MIL-STD-1472C: Sections 4.4(f) and 5.9.4.5

Recommendation: The water/coolant fill should be placed on top of the acoustical box, so the radiator can be checked and serviced externally.

5. Problem: The fender walls on the trailer are located too close to the tires. You have to jack up the fender to pull off the tires. This requirement would severely degrade your mobility in a tactical situation.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: The fender walls on the trailer should be redesigned so that it's easier and quicker to change tires.

6. Problem: The trailer is too large for the generator. Also, the hook-up mechanism on the trailer is not compatible with the size and weight of the generator/trailer. Hooking the heavy generator/trailer to a tow vehicle is a slow and difficult process. For instance, raising the landing-gear tires to the towing position is very time consuming. In addition, 3 or 4 people are needed to load and unload the generator/trailer onto a tow vehicle.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: The size and weight of the generator should be made compatible with the size and weight of the trailer. The hook-up mechanism should be redesigned so that it facilitates setting up the generator and preparing it for transit. These changes would improve the mobility of the generator/trailer in tactical situations.

b. Non-critical Problems

1. Problem: The operator's panel lights are not bright enough to effectively illuminate the control panel at night. Integral lights are not provided inside the gauges.

Violations of MIL-STD-1472C: Sections 4.4(h), 5.1.1.5, and 5.2.1.2.1.1

Recommendation: Use external white lights on the operator's panel and low luminance, integral red lights for all gauges. The brightness of all lights should be adjustable and all lights should be extinguishable with on-off switches. This light configuration would allow maximum flexibility for operating during daytime, nighttime, and blackout conditions.

2. Problem: The generator has no fuel selector switch, so it cannot run off an auxiliary fuel supply.

Violation of MIL-STD-1472C: Section 4.4(m)

Recommendation: Place a fuel selector switch on the generator to increase its tactical flexibility.

3. Problem: The workspaces in front of the operator's panel and on the sides of the generator are totally inadequate. There is no platform or acceptable walking space in front of the operator's panel. The workspace on the side of the generator is obstructed by the presence of a junction box.

Violations of MIL-STD-1472C: Sections 4.4(d) and 4.4(i)

Recommendation: Move the operator's panel to the side or to the rear of the generator. Add a pull-down step to serve as a platform at the new location of the control panel. Move the junction box to the front of the generator (i.e., near the trailer tongue) so it will be near the power connections.

4. Problem: There is an inadequate amount of storage space on the generator/trailer.

Violations of MIL-STD-1472C: Sections 4.4(d) and 5.9.1.2

Recommendation: Increase the storage space to accommodate more fuel cans, special tools, grounding rods, and an operator's manual.

6.1.3.24 Manufacturer J, 60 kW, 60 Hz Generator

6.1.3.24.1 Ratings Made By Three Operators

a. Environment. In general, the operators gave "Somewhat too high" and "Much too high" ratings for the noise levels of the generator when the baffles and doors were closed and when they were open. In general, the operators gave "Acceptable" ratings for the vibration level and temperature level near the generator during normal operations. The three operators gave "About right" ratings for the daytime and nighttime light levels at the operator's panel during normal conditions.

b. Indicator Lights. In general, the operators gave "Adequate" ratings for the indicator lights.

c. Gauges. In general, the operators gave "Adequate" and "Very Adequate" ratings for the gauges.

d. Controls. In general, the operators gave "Adequate" and "Very Adequate" ratings for the controls.

e. Power Connections. The three operators gave "Adequate" ratings for the power connections.

f. Equipment Location. One operator gave "Inadequate" ratings for the location of the operator's control panel, the Start-Stop switch, and the Emergency Stop-Run switch. The same operator gave "Very Inadequate" ratings for the configuration on the trailer and the location of the fuel fill.

g. Workspace and Storage Space. The three operators gave "Adequate" and "Very Adequate" ratings for the amount of workspace within the acoustical enclosure. Two operators gave "Inadequate" ratings for "Platforms, walking spaces, footholds, and handholds on generator/trailer for mounting generator to perform duties." One operator gave "Very Inadequate" ratings for the amount of storage space provided for fuel cans, tools, spare parts, and manuals.

h. Operational Procedures. One operator gave "Difficult" and "Very Difficult" ratings for setting up generator and preparing for starting, preparing generator for transit, and transporting generator.

i. Maintenance Procedures. In general, the operators were satisfied with the effort required in performing PMCS. Most items were rated as being easy to perform.

j. Operator's Manual. Two of the three operators used a manual; the other operator said that no manual was present with the generator. The two operators who used the manual were satisfied with it and rated it as follows--"accurate," "comprehensive," "effective," and "easy to understand."

k. Tools. One operator was displeased that special tools were not provided with the generator.

1. Trailer

1. The operators were generally dissatisfied with the trailer--giving "Inadequate" and "Very Inadequate" ratings to the following items: Hook-up mechanism, Protective cover over lugs, Brakes, and Design features for mounting trailer safely. One operator also gave "Inadequate" ratings for "Height of chassis above ground," "Sturdiness of trailer," "Tire Size," and "Location of power box on trailer."

2. The three operators gave "Adequate" and "Very Adequate" ratings for the following items: Length of trailer, Width of trailer, Tire Configuration on each side, Labeling of Lugs, Size of Lugs, Connections on Lugs, and Fuel Storage.

6.1.3.24.2 Comments Made By Three Operators

a. Environment

1. Two operators commented: Noise levels with doors open and with doors closed are too high for tactical operations.

2. One operator commented: The two, white panel lights on the operator's control panel are too bright--they interfere with light discipline and dark adaptation during tactical operations at night. Designers should use green lights or a light deflector to deflect the light down onto the control panel.

3. One operator commented: It is somewhat difficult to get the fuel spout into the fuel fill because of the vibration level of the generator.

b. Indicator Lights. No comments

c. Gauges. No comments

d. Controls

1. One operator commented: The control for starting should be a pushbutton labeled "push to start" instead of the present oblong switch with several settings on it. Presently, the operator must worry about which way to turn the switch.

2. One operator commented: The throttle is located too far away from the frequency meter on the control panel. The operator has to crane his neck in order to see the meter as he adjusts the throttle. Suggestion: Reorient the frequency meter so that it can be seen easily by the operator when he adjusts the throttle.

3. One operator commented: The generator has a tendency to drop off rpm's after running a long time--the lock screw on the throttle vibrates loose. Many re-adjustments are required to maintain the generator at 60 Hz. Suggestion: Place a new locking device on the throttle to stabilize the frequency.

e. Power Connections. Two operators commented: When the power cables are connected to the lugs, the hinged, protective cover over the lug area is held in an "up" position--allowing a long crack between the cover and the side of the generator box. Rain can get through this crack and seep into the lug area. In the field, we tied a piece of cardboard over the crack to keep water out. Otherwise, it could have caused an electrical shock. Suggestion: Replace present cover with a waterproof cover, such as the standard 60 KW cable sock entry to the generator hook-up area.

f. Equipment Location

1. One operator commented: The location of the power connection lugs is poor--i.e., below the operator's control panel. This is a highly-trafficked area for the operator and unnecessarily exposes him to high electrical shock hazards. Suggestion: Relocate power connection lugs to a lesser-trafficked area.

2. One operator commented: The operator's control panel, along with its indicator lights, gauges, and controls, is too high. The panel cannot be reached easily by average-height males and females.

3. One operator commented: In the field, 6 men were unable to pick up the tow area of the generator because its weight is not centered on the trailer. The generator is too heavy toward the front of the trailer. This unequal weight distribution causes problems during transport and placement, and could create a safety hazard since there is only one jackstand on the tongue of the trailer. Suggestion: Move weight back to center it on trailer and add another jackstand.

4. Three operators commented: The fuel fill, fuel gauge, and fuel vent are located inside the acoustical doors of the generator and all are too close together. They should be located outside and spread apart more. An external fuel overflow valve is needed so that fuel does not get inside the generator housing. The fuel gauge is not only located poorly, but is also a poor type of gauge.

5. One operator commented: The spare tire is located at the front of the trailer in a good location that is very accessible.

6. One operator commented: Good features include: a) locking mechanism for fuel system; b) lock on doors, and c) locations of fuel, oil, and water drains--i.e., they are all outside the acoustical box around the generator.

7. One operator commented: Having the operator's panel behind a door was a good feature because this kept the panel out of the elements.

g. Workspace and Storage Space

1. Three operators commented: Walking spaces over and around the tires are too narrow and slippery. The walking spaces need to be widened to at least three feet and be made of a nonskid surface. It is difficult to balance on the present walkways especially if you have diesel and water cans on them.

2. One operator commented: There is no storage space on the generator for tools, spare parts, manuals, etc.

h. Operational Procedures. Two operators commented: When the doors are open, they move freely with the wind or vibration of the generator. Also, when the engine is running, the doors are sucked in. The free movement of the doors create safety hazards--such as getting fingers caught, being pushed into hot and moving parts of the engine, etc. Suggestion: Tie downs or straps are needed so that doors can be fastened when in the "opened" position.

i. Maintenance Procedures

1. One operator commented: The oil fill should be tilted more so it is easier to put oil in. Presently it is hard to put oil in if you don't have a funnel.

2. One operator commented: The air vent should be changed so that a fuel overflow does not spray the soldier filling the fuel tank. I was watching an inoperative fuel gauge while refueling and the fuel sprayed all over my arm from the 4-foot vent.

j. Operator's Manual. No comments.

k. Tools. One operator commented: No special tools came with unit. Two heavy duty wrenches are needed to adjust the height of the trailer hook. Also, we need a hex wrench to hook up cables.

l. Trailer

1. Two operators commented: The trailer hook needs to protrude out about 6 more inches and the safety chains lengthened, so it would be easier to turn the generator/trailer with a 5-ton truck.

2. One operator commented: The locking switch for the air brakes is too easy to unlock. Suggestion: Replace the present switch with a switch more resistant to movement or replace entire air brake system with a manual system. [Manual brakes are preferred to air brakes because with air brakes you can't tell if any air is in the system. If the switch has been tampered with, you will have no brakes and won't know it.]

3. One operator commented: The brakes were not labeled.

4. One operator commented: The trailer is too low to the ground. If you are going cross-country, you may scrape bottom and puncture the fuel tank. A larger set of tires would raise the whole trailer and provide more support. Also, the axles are not heavy enough.

5. Three operators commented: The fender skirts are too close to the tires. If they are bent inward during movement, a tire puncture could result. Also, the fender walls should not be at a 90° angle on the bottom, but at a 40° angle or rounder. This would prevent tire punctures while driving over rough terrain.

6. Three operators commented: The surfaces of the fender skirts are slippery. Suggestion: Put slip-resistant surface on fender skirts.

7. One operator commented: No step is provided for mounting the fender skirts to perform operator maintenance. Suggestion: Put step at rear of fender skirt.

6.1.3.24.3 Ratings Made By Three Drivers

a. The three drivers gave "Easy" and "Very Easy" ratings for the towability of the generator/trailer on straight paved roads at speeds below 25 mph and above 25 mph. One driver gave a "Difficult" rating for the towability around curves on paved roads. In general, the drivers were satisfied with the towability on straight gravel roads at speeds below 25 mph. No driver drove the generator/trailer at speeds above 25 mph on straight gravel roads. One driver was dissatisfied with the towability around curves on gravel roads and the ability to back up with the generator/trailer attached.

b. In general, the drivers were satisfied with the overall size and weight of the trailer, shape of the trailer, sturdiness of trailer, tire configuration, brakes, and design features for mounting the trailer safely. One driver was dissatisfied with the hook-up mechanism.

6.1.3.24.4 Comments Made By Three Drivers

a. One driver commented: The hook-up eyelet did not stick out far enough to allow clearance of the trailer's A-frame from the bumpers on the truck when sharp turns were made.

b. One driver commented: Safety chains on the trailer were too short.

c. One driver commented: The fender around the wheel comes too close to the wheel. If the fender gets bent while going cross-country, it might puncture a tire.

6.1.3.24.5 Analysis

Analysis of the preceding results led to the identification of human factors problems and the classification of these problems into the following critical and non-critical categories:

a. Critical Problems

1. Problem: The noise levels with access doors closed and with them open are too high for tactical operations--i.e., dB(A) at the operator's panel with doors closed is 88; with doors open it is 104 dB(A).

Violation of MIL-STD-1472C: Section 5.8.3.1

Recommendation: Before further consideration is given to this generator, the manufacturer should retrofit it with a better acoustical package.

2. Problem: The fuel fill, fuel gauge, and fuel vent are all located inside the acoustical enclosure. Also, the fuel fill and fuel vent are too close together. If the fuel tank is accidentally overfilled, the operator can be sprayed with fuel from the fuel vent.

Violation of MIL-STD-1472C: Section 4.9.4.5

Recommendation: Relocate the fuel fill, fuel gauge, and fuel vent to the outside of the acoustical enclosure and separate the fuel vent from the fuel fill and fuel gauge.

3. Problem: The generator is too front-heavy. This unequal weight distribution causes problems during transport and placement.

Violation of MIL-STD-1472C: Section 5.12.8.1

Recommendation: The center-of-gravity of the generator should be determined so that the generator can be properly positioned on the trailer.

b. Non-critical Problems

1. Problem: The throttle is located too far away from the frequency meter on the operator's control panel. The operator cannot readily see the meter when he adjusts the throttle.

Violations of MIL-STD-1472C: Sections 5.1.1.1, 5.1.2.3.3, and 5.2.1.4.3

Recommendation: Relocate the throttle or reorient the frequency meter so that the operator can readily see the visual display (i.e., frequency meter) while he manipulates the control associated with it (i.e., throttle).

2. Problem: The operator's control panel is too high off the ground. Average-height males and females cannot reach the controls readily nor can they view the gauges from a proper angle. Of special concern is the excessive height of the Emergency Stop-Run switch.

Violations of MIL-STD-1472C: Sections 3.1, 5.2.1.4.1, 5.2.1.4.2, 5.1.2.3.8, and 5.7.2.3

Recommendation: Lower the operator's control panel so that shorter personnel can operate the equipment effectively.

3. Problem: Walking spaces around the fender skirts on trailer are too narrow and slippery. It is difficult for operators to balance themselves on the walkways while they perform operator maintenance.

Violations of MIL-STD-1472C: Sections 5.14.2.3. and 5.7.7.6

Recommendation: Widen the walkways around the fender skirts to at least 27 inches and treat the exterior personnel platforms with a nonskid material conforming to specification MIL-W-5044.

4. Problem: There is no storage space on the generator/trailer.

Violation of MIL-STD-1472C: Section 5.9.1.2

Recommendation: Storage space should be provided for special tools, spare parts, fire extinguishers, grounding rods, fuel, oil, water, and other maintainability items.

5. Problem: The access doors move freely when in the "opened" position.

Violation of MIL-STD-1472C: Section 5.9.12.9

Recommendation: The access doors should be provided with braces or some other type of positive locking mechanism to keep the doors securely opened when access to generator is needed.

6. Problem: The oil fill is straight up and down. It is hard to fill with oil if you don't have a funnel.

Violation of MIL-STD-1472C: Section 4.4(f)

Recommendation: The oil fill should be tilted more.

7. Problem: Special tools were not provided with the generator.

Violation of MIL-STD-1472C: Section 5.9.1.2

Recommendation: Special tools, such as heavy duty wrenches and hex wrenches, should be provided with the generator/trailer.

8. Problem: The trailer hook does not protrude out far enough. This design limits the maneuverability of the trailer when the tow vehicle tries to make a sharp turn.

Violation of MIL-STD-1472C: Section 4.9

Recommendation: Lengthen the trailer hook at least 6 more inches and make a comparable adjustment to the length of the safety chains.

9. Problem: The trailer is too low to the ground. When it is driven cross-country, the bottom may be scraped and the fuel tank may be punctured.

Violation of MIL-STD-1472C: Section 4.9

Recommendation: The chassis should be raised off the ground more by redesigning the trailer or using a larger set of tires.

10. Problem: The brakes on the trailer are not labeled.

Violation of MIL-STD-1472C: Section 5.5.1.1

Recommendation: The brakes should be labeled.

11. Problem: The fender skirts are too close to the tires. When the trailer is driven cross-country, a fender skirt could be bent inward—causing a puncture to a tire.

Violation of MIL-STD-1472C: Section 4.9

Recommendation: The trailer should be redesigned so that the fender skirts are a "safe" distance from the tires.

12. Problem: No step is provided for mounting the fender skirts to perform operator maintenance.

Violation of MIL-STD-1472C: Section 4.4(f)

Recommendation: Put steps at the rear of the fender skirts.

6.1.3.25 Manufacturer I, 100 kW, 60 Hz Generator

6.1.3.25.1 Ratings Made By Three Operators

a. Environment. The three operators gave "Acceptable" ratings for the noise levels of the generator when the baffles and doors were closed and when they were open. The three operators gave "Acceptable" ratings for the vibration level and temperature level near the generator during normal operations. The three operators gave "About right" ratings for the daytime light levels at the operator's panel during normal conditions; however, two operators expressed dissatisfaction with the nighttime light levels at the operator's panel.

b. Indicator Lights. In general, the operators gave "Adequate" and "Very Adequate" ratings for the indicator lights. However, one operator was dissatisfied with the brightness of the indicator lights during daytime and nighttime operations.

c. Gauges. In general, the operators gave "Adequate" and "Very Adequate" ratings for the gauges. However, one operator was dissatisfied with the brightness of certain gauges during nighttime operations.

d. Controls. The three operators gave "Adequate" ratings for the controls, except that one operator rated the labels as "Neither Adequate Nor Inadequate."

e. Power Connections. The three operators gave "Adequate" ratings for the power connections.

f. Equipment Location. In general, the operators gave "Adequate" and "Very Adequate" ratings for the location of equipment. However, one operator gave "Inadequate" ratings for the location of batteries, storage compartments, oil fill, and water/coolant fill.

g. Workspace and Storage Space. There was a great deal of variability in the ratings given in this category--with ratings for most items varying from "Inadequate" to "Adequate." Two operators gave "Adequate" ratings for the amount of workspace within the acoustical enclosure and the amount of storage space for the grounding rods. Two operators gave "Inadequate" and "Very Inadequate" ratings for the design of generator/trailer for mounting generator to perform duties and the amount of storage space provided for fuel cans.

h. Operational Procedures. The three operators gave "Easy" and "Very Easy" ratings for the following items: Start up generator electrically, Stop generator normally, and Operate generator while performing other duties. Most of the other items were given two or three "Did Not Perform" ratings, so the results for these operational procedures are inconclusive.

i. Maintenance Procedures. The three operators gave "Easy" and "Very Easy" ratings for the following items: Check instruments for normal operation, Check engine oil, Check for fuel leaks, and Refuel generator. One operator gave "Difficult" ratings for checking batteries, checking radiator, and servicing radiator. Most of the other items were given two or three "Did Not Perform" ratings, so the results for these maintenance procedures are inconclusive.

j. Operator's Manual. Summary statements about the operator's manual cannot be made since one operator stated that a manual was present with the generator, one stated that a manual was not present, and another stated that he did not know if a manual was present.

k. Tools. One operator gave a "Very Inadequate" rating for normally-issued tools and their sufficiency for performing operator PMCS. Another operator gave an "Inadequate" rating for normally-issued tools and their sufficiency for troubleshooting. Summary statements about the tools cannot be made since several "Don't Know" ratings were made.

l. Trailer. There was a great deal of variability in the ratings given for the trailer. Three operators gave "Adequate" and "Very Adequate" ratings for the following items: Overall Size and Weight of Trailer, Width of Trailer, Hook-up Mechanism, Location of Power Box on Trailer, and Suitability of Power Box for General Use. Two operators gave "Inadequate" ratings for the length of the trailer. One operator gave "Very Inadequate" ratings for the height of chassis above ground and fuel storage. One operator gave "Inadequate" ratings for the following items: Sturdiness of Trailer, Tire Configuration on Each Side, Tire Size, Protective Cover over Lugs, and Design Features for Mounting Trailer Safely.

6.1.3.25.2 Comments Made By Three Operators

a. Environment

1. One operator commented: The nighttime light level at the operator's panel is "Somewhat too low" because some of the gauges have lights and some don't. You have to use a flashlight to see those that don't have lights.

2. One operator commented: The voltage, amperage, and frequency meters were not lit up at night. They should be lit up because the operator has to adjust the Hz and voltage meters at night. If the soldier doesn't have a flashlight with him, he's just out of luck—because there are no internal lights on the meters and no external lights on the operator's panel to light up the meters externally.

b. Indicator Lights. One operator commented: The red lights in the 100 amp boxes that they put on the ground were inadequate during daylight. You had to put your hands over the lights to see if they were lit.

c. Gauges

1. One operator commented: The brightness of the gauges was very adequate during daylight. You have no problems seeing what you need to see at a glance.

2. One operator commented: The voltage, amperage, and frequency meters were not lit up at night. They should be lit up internally because the operator has to adjust the Hz and voltage meters at night.

3. One operator commented: The gauges that were lit up were adequate, but some gauges didn't have any lights and they should have had them.

d. Controls. One operator commented: The starter switch is not labeled.

e. Power Connections

1. One operator commented: We had problems initially because of differences in phases between military systems and civilian systems.

2. One operator commented: If the cables were a whole lot smaller, they'd be easier to work with.

f. Equipment Location

1. One operator commented: The location of the batteries is inadequate because they are difficult to get to for maintenance purposes.

2. One operator commented: The oil fill is inadequate. We had to make our own handmade funnel because we had no way of putting the oil in easily--especially when filling from a 5-gal can of oil.

3. One operator commented: The location of the water/coolant fill is inadequate. We had to climb on top of the generator itself without the aid of any footholds or handholds. Then, we had to stand on top of the cover for the operator's panel--and you could slip off fairly easily.

g. Workspace and Storage Space

1. One operator commented: There's not enough room within the acoustical enclosure for working around the generator. Maybe the box needs to be a little wider on the inside.

2. One operator commented: There are no handholds or footholds for climbing on top of the generator to perform duties. You need to weld handholds and footholds to the rear corners of the acoustical box.

3. One operator commented: The acoustical box needs a small ladder attached to it so the operator can get on top of the generator.

4. One operator commented: The storage compartment is inadequate. There is 1 small tool box up front and that is about it. We need room for more tools, fuel cans, water cans, oil cans, etc. Anything that goes with the generator should be stored on it, so nothing is left back in the rear and forgotten about.

5. One operator commented: There are no storage compartments. There's just a little bitty box in front for the chock blocks. There should be a bigger storage area for storing fire extinguishers, manuals, tools, spare parts, etc.

h. Operational Procedures

1. One operator commented: When switching power output from 1 generator to the other in a pair, we had to shut down our computers, switch over the generators, and then bring the computers back up. It would be nice to be able to switch from 1 generator to the next without having a power loss or surge. A loss of power and a power surge are both bad for our computers.

2. One operator commented: This generator had few unexpected power surges. This is good for running computers because we are able to concentrate on other duties.

i. Maintenance Procedures

1. One operator commented: Checking batteries is difficult. When you unfasten the straps around the batteries, you can easily drop the straps down into the acoustical box--they are difficult to retrieve. If you pull the battery cover off and drop it inside the acoustical box, it is difficult to retrieve also. It is difficult to get to the bottom battery since it is stored directly underneath the top battery. You have to remove the top one to get to the bottom one.

2. One operator commented: Checking and servicing the radiator is difficult because you have to climb up on top of the generator without the aid of handholds or footholds. After you've climbed up there, someone else has to hand you the water cans. Thus, checking and servicing the radiator is a two-man operation.

3. One operator commented: The fuel fill needs a larger hole. The present fuel fill is about the same size as the nozzle used to fill the fuel tank. Consequently, a great deal of fuel is spilled on the outside of the generator/trailer during the refueling process.

4. One operator commented: There should be an easier way to open the side doors in order to perform maintenance.

j. Operator's Manual. One operator commented: We had a problem with the phases. The way the manual tells you to set it up and how you actually have to set it up--are two different things. If you really followed the manual, you wouldn't set it up right. You have to know a little bit about it before you can set it up.

k. Tools

1. One operator commented: Too few tools were provided for setting up the generator. We needed Allen wrenches and other tools like those readily found in the motor pool, but not in our field area. So, we had to go find some tools and then come back to set up the wiring and all that stuff.

2. One operator commented: The generator should have its own tools, but none came with this generator. It should have a sledge hammer for driving in the ground rod, a shovel, fire extinguishers, water containers, etc.

l. Trailer

1. Two operators commented: The length of the trailer is inadequate. It is too long for going up and down rough terrain.

2. Two operators commented: The height of the chassis above ground is very inadequate. The ground clearance is way too low. For military operations, you're going to go into a rougher area than a normal commercial generator goes into. You've got to have something for off-road use. This trailer made it back here, but if we had to go to a rougher area, the trailer might cause a lot of troubles.

3. One operator commented: The tire size is inadequate. I recommend using larger tires so the ground clearance will be a bit higher.

4. One operator commented: The design features for mounting the generator/trailer safely are inadequate. Handholds and footholds are needed if operators are expected to climb on top to check and service the radiator.

5. One operator commented: The sturdiness of the trailer is inadequate. It needs more than 2 wheels on each side, because in rough terrain we could go over a high bump and the generator could tip over. With more tires on each side, it would be sturdier.

6.1.3.25.3 Drivers' Ratings

No driver of this 100 KW generator was surveyed since pertinent ratings were obtained from drivers of a similar, 30 KW generator.

6.1.3.25.4 Drivers' Comments

No driver of this 100 KW generator was surveyed since pertinent comments were obtained from drivers of a similar, 30 KW generator.

6.1.3.25.5 Analysis

Analysis of the preceding results led to the identification of human factors problems and the classification of these problems into the following critical and non-critical categories:

a. Critical Problems

1. Problem: The labeling scheme for the load terminals is different from the labeling scheme used for military generators.

Violation of MIL-STD-1472C: Section 5.5.1.1

Recommendation: Make the label for a designated terminal on this generator consistent with the label for the corresponding terminal on a military standard generator.

2. Problem: The access doors are too difficult to open and close for normal maintenance and emergency purposes. The multiple-turn latches are slow to operate and unreliable as a means of closure.

Violations of MIL-STD-1472C: Sections 4.4(m), 5.9.9.2, 5.9.9.4.1(b) and 5.9.12.9

Recommendation: The access doors should be self-supporting so they can be opened quickly and easily. They should be hinged on one side and latched on the other (with tongue-and-slot catches). The doors should have positive locks or braces to secure them when they are in the "opened" position.

b. Non-critical Problems

1. Problem: The voltage, amperage, and frequency meters are not lit up at night.

Violations of MIL-STD-1472C: Sections 4.4(h), 5.1.1.5, and 5.2.1.2.1.1

Recommendation: Use 3 or 4 external white lights on the operator's panel and low luminance, integral red lights for all gauges. The brightness of all lights should be adjustable and all lights should be extinguishable with on-off switches. This light configuration would allow maximum flexibility for operating during daytime, nighttime, and blackout conditions.

2. Problem: The starter switch is not labeled.

Violation of MIL-STD-1472C: Section 5.5.6.2.3

Recommendation: This control should be labeled according to its function.

3. Problem: The water/coolant fill is located near the top rear of the generator, beneath the baffling for the air intake and exhaust. There are no handholds or footholds to be used for mounting the generator. Thus, it is not designed for maintainability.

Violations of MIL-STD-1472C: Sections 4.4(f) and 5.9.4.5

Recommendation: Relocate the water/coolant fill so that the radiator neck is directly on top of the acoustical enclosure, but away from the air intake/exhaust area. Place handholds and footholds on sides of the generator.

4. Problem: The batteries are difficult to access for maintenance purposes. One battery is stored directly underneath the other battery. You have to remove the top one to get to the bottom one.

Violations of MIL-STD-1472C: Sections 4.4(f) and 5.9.4.5

Recommendation: Create a separate compartment for the batteries, so they can be mounted side-by-side. The compartment should allow the batteries to slide in and out easily so they can be accessed individually without difficulty.

5. Problem: The storage space on the generator/trailer is too small. The chock blocks may be stored, but the generator/trailer can store few other items for maintainability of generator.

Violation of MIL-STD-1472C: Section 5.9.1.2

Recommendation: Storage space should be provided for special tools, spare parts, fire extinguishers, grounding rods, fuel, oil, water, and other maintainability items.

6.4.6.2 MEP-005A, 30 KW, 60 Hz Generator with Large Muffler

This generator is identical to the one just discussed in Section 6.4.6.1, except that it has a large muffler rather than baffles for reducing noise. Consequently, the information found in that section, with the exception of information pertinent to baffles, applies here.

6.4.6.5 MEP-114A, 30 KW, 400 Hz Generator

Since this generator was only briefly used on the field exercise of the test, there were no operators with experience on it who could provide reliable and valid human factors data on it. However, from an operator's point of view, the generator is identical to the MEP-115A, 60 KW, 400 Hz generator. Consequently, the information in section 6.1.7.1 also applies to this generator.

CHAPTER 7

7. Safety

7.1 Issue. Are generator sets safe to operate and maintain?

7.1.1 Criteria.

7.1.1.1 Cooling outlet air and exhaust gases must be directed or controlled to facilitate ducting or venting when units are used in confined areas.

7.1.1.2 The sets will not present any safety hazard to users during fueling and refueling operations.

7.1.2 Methodology.

7.1.2.1 Human factors psychologists completed a System Safety Checklist for each type of generator system and summarized the results for each type. [A copy of the System Safety Checklist is available upon request from the Army Research Institute Field Unit - Fort Hood, Texas.]

7.1.2.2 Near the end of each field exercise, human factors psychologists administered safety questionnaires (section VIII of the Human Factors and Safety Questionnaire) and conducted structured interviews with the operators of each type of generator system. Ratings and comments were obtained about the adequacy of each system with respect to safety. The ratings for each generator system were tabulated for each safety question in each rating category. Operators' comments from the questionnaires and interviews were categorized and summarized.

7.1.2.3 During the field exercises, sound level measurements were taken for each generator at a distance of one foot from each side, with all doors and panels closed. A minimum of four sound measurements was taken for each generator (one per side) with a Quest Electronics Sound Level Meter, Model 215, using slow meter damping. For each measurement, the sound level meter was held at an above-ground height of approximately five feet. If the sound level reached or exceeded 85 dB(A) at a distance of one foot, the distance at which the sound level dropped to 85 dB(A) was determined so that an 85 dB(A) contour around the generator could be established. Because the requirement for obtaining sound levels on all of the generators was received near the end of the test, it was not possible to record sound levels under identical conditions for all generators, nor was it possible to record sound levels from all generators while they were under load. Measurement conditions of load or no-load are indicated for each generator in the "Results and Analysis" section.

7.1.2.4 Every identified safety hazard was classified according to the four categories of hazard severity and the six levels of hazard probability as specified in MIL-STD-882A. The classification categories and levels are listed below:

Hazard Severity

Category I - Catastrophic
Category II - Critical
Category III - Marginal
Category IV - Negligible

Hazard Probability

Level A - Frequent
Level B - Reasonably Probable
Level C - Occasional
Level D - Remote
Level E - Extremely Improbable
Level F - Impossible

7.1.3 Results and Analysis. The hazard classifications for each type of generator are summarized in Table 7-1. Summaries of the System Safety Checklist, safety questionnaire and interview results, and sound level measurements are presented in the following paragraphs. Analysis and classification of hazards follow the detailed descriptions of safety problems.

TABLE 7-1. CLASSIFICATION OF SAFETY PROBLEMS

Mfr.	Size	Electrical shock		Heat		Sharp edges and corners		Moving parts		Loudness		Noxious fumes		Size or weight		Batteries		Floor surfaces		Fire		Other hazards		
		III-C	III-B	III-C	III-B	II-C	II-B	III-C	III-B	III-D	III-B	III-C	III-C	III-C	III-B	III-C	III-B	III-C	III-B	III-D	III-C	III-D	III-C	III-D
A	1.5 kW DC skid	--	--	--	--	II-C	III-D	--	--	III-C	--	--	--	--	--	--	--	--	--	--	--	--	--	--
A	1.5 kW DC boxed	III-C	III-B	III-C	III-B	--	--	--	--	III-C	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B	3 kW 28 DC	--	II-D	III-C	--	--	--	--	III-D	--	--	II-B	II-C	--	--	--	--	--	--	--	--	--	--	--
A	3 kW, 60 Hz	I-C	--	I-C	--	II-C	--	III-C	--	III-D	III-C	--	III-C	--	--	--	--	--	--	--	--	--	--	--
C	3 kW, 60 Hz	I-C	--	I-C	--	III-C	--	III-C	--	III-D	III-C	--	II-B	II-C	--	--	--	--	--	--	--	--	--	--
D	3 kW, 60 Hz	I-C	--	I-C	--	--	--	--	III-D	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C	5 kW, 60 Hz	I-D ^a	III-C	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
D	5 kW, 60 Hz	III-C	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
E	5 kW, 60 Hz	I-C	--	I-C	--	--	--	--	--	III-B	--	--	--	--	--	--	--	--	--	--	--	--	--	--
F	5 kW, 60 Hz	III-D	--	I-C ^a	--	III-C	II-C	III-D	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
A	10 kW, 60 Hz	I-C	--	I-D	--	III-C	--	III-D	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
D	10 kW, 60 Hz	I-D	--	I-C	--	III-C	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
E	10 kW, 60 Hz	III-D ^a	--	I-C ^a	III-C	III-C	II-C	III-C	III-D	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
A	15 kW, 60 Hz	I-D	--	I-C	--	III-C	II-C ^a	III-D	I-D	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B	15 kW, 60 Hz	--	--	I-C ^a	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
F	15 kW, 60 Hz	--	--	I-C	--	III-B	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
A	30 kW, 60 Hz	I-C	--	I-C	--	III-C	II-C ^a	III-D	II-D	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
A	30 kW, 60 Hz (muffler)	I-C ^a	--	I-C	--	III-C	II-C ^a	III-D	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
AQ	30 kW, 60 Hz	I-C	--	I-C	--	III-C	II-C	--	I-D	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
AW	30 kW, 60 Hz	--	--	I-C	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C	30 kW, 60 Hz	--	--	I-C ^a	I-C	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

TABLE 7-1 (CONT.). CLASSIFICATION OF SAFETY PROBLEMS

Mfr	Size	Electrical shock	Heat	Sharp edges and corners	Moving parts	Loudness	Noxious fumes	Size or weight	Floor surfaces	Batteries	Fire	Other hazards
H	30 kW, 60 Hz	--	--	--	--	--	--	II-B	--	--	--	III-C
		I-C ^a	II-C	III-C	II-C	--	--	II-C	--	--	I-C	II-C ^a
I	30 kW, 60 Hz	--	--	--	--	--	--	--	--	--	--	II-D
		I-C	III-C	--	--	--	--	II-B	--	--	--	I-D
A	60 kW, 400 Hz	--	--	--	--	--	--	I-C	II-D	--	--	III-B
		I-D	--	--	--	--	--	II-D	--	--	--	II-D
H	60 kW, 60 Hz	I-C ^a	II-C	III-C	II-C	--	--	--	--	--	--	III-C
		--	--	--	--	--	--	II-C	--	--	--	II-C
J	60 kW, 60 Hz	III-D	--	--	III-B	--	--	--	--	--	--	III-C
		I-D	--	--	--	--	--	III-C	--	--	--	III-C
I	100 kW, 60 Hz	--	--	I-C	II-C	III-D	--	I-D	--	II-C	II-D ^b	II-C
		I-C	--	--	--	III-C	--	--	--	--	--	--
		--	--	--	--	II-C	--	I-C	--	--	--	III-B
		--	--	--	--	--	--	--	--	--	--	I-D

^aThis problem reported twice with this classification.^bThis problem reported three times with this classification.

7.1.3.1 Manufacturer A, 1.5 kW, 28 vDC Generator, Modified, Skid-Mounted

7.1.3.1.1 System Safety Checklist

- a. There is no green indicator light to indicate when power is on.
- b. The main power switch is not clearly identified with a "Main Power On-Off" label.
- c. The start pulley does not have a safety cover over it.
- d. The generator weighs 121 pounds, but has no lift restriction stencil on it.

7.1.3.1.2 Ratings Made By One Operator

The tabulation of operator's responses to the safety questionnaire is shown below.

Table 7-2. Number of operators checking each category in the safety questionnaire (Manufacturer A, 1.5 kW, 28 vDC, Skid-Mounted Generator)

<u>Safety Incident</u>	I Have Experienced	I Have Not Experienced But Is A Problem	Not A Problem	Was Not In A Position To Say
a. Electrical Shock	—	—	1	—
b. Fire or Fire Hazard	—	—	1	—
c. Burns	—	—	1	—
d. Cuts, Scrapes, or Punctures	—	1	—	—
e. Extreme Temperature	—	—	1	—
f. Extreme Brightness	—	—	1	—
g. Extreme Loudness	—	—	1	—
h. Noxious Fumes	—	—	1	—

7.1.3.1.3 Sound Level Measurements

These measurements were taken in the field in conjunction with an infrared photographic test. No load was on the system and the generator was sitting on a small trailer.

<u>Location of Measurement</u>	<u>dB(A) at one foot</u>	<u>Distance from Generator to 85 dB(A) Contour</u>
Operator's panel	94	5 ft. 2 in.
Side to right of operator's panel	97	4 ft. 7 in.
Side opposite to operator's panel	98	6 ft. 6 in.
Side to left of operator's panel	99	4 ft. 7 in.

7.1.3.1.4 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows:

- a. The absence of a green indicator light to indicate when power is on, and the lack of a "Main Power On-Off" label on the main power switch, may cause a lack of awareness as to whether or not electrical power is being applied to the power distribution system. The deficiencies could lead to a soldier's being shocked. Since the generator only produces 28 volts DC, these problems are classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.
- b. The start pulley does not have a safety cover over it. A soldier could be seriously injured by either falling against the pulley or getting his clothing caught in it. This hazard is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.
- c. The generator is skid mounted and small enough to be moved manually. It weighs 121 pounds which exceeds the weight design limit (50 pounds) specified in MIL-STD-1472C for a single male soldier lifting an item four feet in the air; consequently, the generator should have its weight listed as part of a CAUTION stencil. The stencil should be conspicuously placed on the generator to help prevent injury to personnel. This problem is classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.
- d. Sound levels near the generator exceed 85 dB(A), the upper limit for steady state noise specified in MIL-STD-1474B(MI). Hearing protection is required for soldiers working close to this generator and CAUTION signs stating the requirement should be posted on the generator. This problem is classified as Category III, Marginal with respect to hazard severity and as Level D, Remote with respect to hazard probability.

7.1.3.2 Manufacturer A, 1.5 kW, 28 vDC Generator, Modified, Boxed

7.1.3.2.1 System Safety Checklist

- a. There is no green indicator light to indicate when power is on.
- b. The main power switch is not clearly identified with a "Main Power On-Off" label.
- c. The generator weighs 125 pounds, but has no lift restriction stencil on it.

7.1.3.2.2 Ratings Made By Two Operators

The tabulation of operators' responses to the safety questionnaire is shown below.

Table 7-3. Number of operators checking each category in the safety questionnaire (Manufacturer A, 1.5 kW, 28 vDC, Boxed Generator)

<u>Safety Incident</u>	I Have Experienced	I Have Not Experienced But Is A Problem	Not A Problem	Was Not In A Position To Say
a. Electrical Shock	—	—	2	—
b. Fire or Fire Hazard	—	—	2	—
c. Burns	1	—	1	—
d. Cuts, Scrapes, or Punctures	—	1	1	—
e. Extreme Temperature	1	—	—	—
f. Extreme Brightness	—	—	1	—
g. Extreme Loudness	—	—	1	—
h. Noxious Fumes	—	2	—	—

7.1.3.2.3 Comments Made By Two Operators

- a. One operator commented: The generator gets too hot to touch after three or four hours.
- b. One operator commented: The generator case heats up after four hours of use in the sun. I got burned once when I touched the case. It was not serious; just a surface burn; no blisters or anything.

c. One operator commented: The area around the exhaust gets hot and charred.

d. One operator commented: There is no fire hazard as long as you pay attention to the exhaust. The exhaust blows out close to the ground, but there isn't any problem as long as it is pointed toward the dirt.

7.1.3.2.4 Sound Level Measurements

These measurements were taken in the field in conjunction with an infrared photographic test. No load was on the system.

<u>Location of Measurement</u>	<u>dB(A) at one foot</u>
Operator's panel	78
Side to right of operator's panel	78
Side opposite to operator's panel	78
Side to left of operator's panel	76

7.1.3.2.5 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows:

a. The absence of a green indicator light to indicate when power is on, and the lack of a "Main Power On-Off" label on the main power switch, may cause a lack of awareness as to whether or not electrical power is being applied to the power distribution system. These deficiencies could lead to a soldier's being shocked. Since the generator only produces 28 volts DC, these problems are classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

b. The generator was designed to be moved manually. It weighs 125 pounds which exceeds the weight limit (50 pounds) in MIL-STD-1472C for a single male soldier lifting an item four feet in the air; consequently, the generator should have its weight listed as part of a CAUTION stencil. The stencil should be conspicuously placed on the generator to help prevent injury to personnel. This problem is classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

c. The generator case gets extremely hot after operating in the sun for several hours. One operator received a mild burn on his hand when he touched it. A CAUTION sign should be placed on the case to warn personnel of high surface temperatures. This problem is classified as Category III, Marginal with respect to hazard severity and as Level B, Reasonably Probable with respect to hazard probability.

d. Exhaust gases are directed out one side of the case, so the surrounding area becomes hot and charred. A fire could start if flammable material were in that area. This problem is classified as Category III, Marginal with respect to hazard severity and as Level D, Remote with respect to hazard probability.

7.1.3.3 Manufacturer B, 3 kW, 28 vDC Generator

7.1.3.3.1 System Safety Checklist

a. The dc power connections on the battery are not color-coded.

b. The noise level at the operator's panel is not less than 85 dB(A); therefore, a person needs ear protection when in the vicinity of the generator.

c. Sharp edges have not been eliminated. The generator needs rubber caps over the starting battery supply terminals (located near the "Battery 24V" label on the output box).

d. The generator does not have a label stating the weight of the unit nor a label indicating the lifting requirements.

7.1.3.3.2 Ratings Made By Ten Operators

The tabulation of operators' responses to the safety questionnaire is shown below.

Table 7-4. Number of operators checking each category in the safety questionnaire (Manufacturer B, 3 kW, 28 vDC Generator)

	I Have Experienced	I Have Not Experienced But Is A Problem	Not A Problem	Was Not In A Position To Say
<u>Safety Incident</u>				
a. Electrical Shock	—	—	10	—
b. Fire or Fire Hazard*	—	—	9	1
c. Burns	1	3	6	—
d. Cuts, Scrapes, or Punctures	1	—	9	—
e. Extreme Temperature	2	—	8	—
f. Extreme Brightness	—	1	9	—
g. Extreme Loudness	—	—	10	—
h. Noxious Fumes	—	1	9	—

*The "Fire or Fire Hazard" category was added to the questionnaire after it had been administered to operators who participated in the Ft. Huachuca exercise.

7.1.3.3.3 Comments Made By Ten Operators

a. One operator commented: I didn't get burned, but something should be put around the frame to prevent operators from grabbing something hot or accidentally leaning on a hot surface.

b. One operator commented: There was a question as to whether it needed to be grounded or not. We didn't know if it was a self-grounding generator or if there needed to be a grounding connector on it. We decided it was self-grounding, since the generator was grounded to the frame and the frame was sitting on the ground. In either case, we didn't have a problem with it in the field.

c. One operator commented: We didn't have any safety problems related to heat, such as getting burned. It was a cool generator and didn't get that hot. On the mil std 4.2 generator, the exhaust pipe will get bright red. This generator was nice and quiet and didn't get hot.

d. Two operators commented: The exhaust pipe gets real hot. I suggest putting a cover over it to keep people from getting burned.

e. One operator commented: The generators that were mounted on trailers were too close together, creating a dangerous situation for the operators. It was very hard to get around the generator at night. It was very dangerous climbing onto the trailer at night because there were not a lot of secure places to walk. There should be more room around the generators and between them for safety.

f. One operator commented: The generator should have red lights on the control panel and near the crank so you can see what you're doing at night. This would help to prevent an injury.

7.1.3.3.4 Sound Level Measurements

These measurements were taken in the field in conjunction with an infrared photographic test. No load was on the system.

<u>Location of Measurement</u>	<u>dB(A) at one foot</u>	<u>Distance From Generator to 85 dB(A) Contour</u>
Operator's panel	96	4 ft. 0 in.
Side to right of operator's panel	93	2 ft 7 in.
Side opposite to operator's panel	89	1 ft 10 in.
Side to left of operator's panel	97	5 ft. 0 in.

7.1.3.3.5 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows:

a. The lack of color coding on the dc power connections for the battery could cause an operator to connect cables to the wrong terminals. The situation creates a safety hazard. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

b. Sound levels near the generator exceed 85 dB(A), the upper limit for steady state noise specified in MIL-STD-1474B(MI). Hearing protection and a "CAUTION HIGH NOISE LEVEL" sign are required. This problem is classified as Category III, Marginal with respect to hazard severity and as Level D, Remote with respect to hazard probability.

c. An individual could receive lacerations if he fell against the starting battery supply terminals that protrude from the output box. These terminals should be covered with protective caps. This problem is classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

d. The manual states that the 3 KW weighs 245 lbs. and is a "two-man portable unit." This is not consistent with the lifting requirements specified in MIL-STD-1472C which specifies 170 pounds as the design limit for the two-man lift of an item one foot in the air. It is recommended that "CAUTION: Unit Weighs 245 lbs" be stenciled on the generator, since two men will probably attempt to lift this small generator. This problem is classified as Category II, Critical with respect to hazard severity and as Level B, Reasonably Probable with respect to hazard probability.

e. Certain parts of the generator such as the exhaust pipe get very hot. Since it is possible to get burned on them, a "CAUTION HIGH TEMPERATURE" sign should be stenciled on the generator. This problem is classified as Category II, Critical with respect to hazard severity and as Level D, Remote with respect to hazard probability.

7.1.3.4 Manufacturer A, 3 kW, 60 Hz Generator, Modified

7.1.3.4.1 System Safety Checklist

- a. There is no green indicator light to indicate when power is on.
- b. Operators and other soldiers are not protected from accidental contact with voltages greater than 30 volts rms (ac). A protective cover is needed over the lugs on the generator.
- c. The area around the main power terminals is not marked with a "CAUTION HIGH VOLTAGE, 120/208 VOLTS" warning.
- d. The main power switch is labeled "Circuit Breaker" rather than "Main Power On-Off."
- e. There is no safety cover over the start pulley.
- f. All exhaust pipes are directed toward the center of the trailer rather than outward. This configuration could lead to a build up of exhaust fumes in a confined area and cause an operator working in the center of the trailer to become ill.
- g. There is no lift restriction sign on the generator.
- h. The floor surfaces of the trailer are not slip-resistant.

7.1.3.4.2 Ratings Made By Operators

The operators of this generator could not be identified. Thus, no ratings are available.

7.1.3.4.3 Comments Made By Operators

The operators of this generator could not be identified. Thus, no comments are available.

7.1.3.4.4 Sound Level Measurements

These measurements were taken in the field in conjunction with an infrared photographic test. No load was on the system.

<u>Location of Measurement</u>	<u>dB(A) at one foot</u>	<u>Distance From Generator to 85 db(A) Contour</u>
Operator's panel	93	4 ft. 1 in.
Side to right of operator's panel	101	6 ft. 4 in.
Side opposite to operator's panel	98	7 ft. 9 in.
Side to left of operator's panel	101	5 ft. 3 in.

7.1.3.4.5 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows:

a. The absence of a green indicator light to indicate when power is on and the lack of a "Main Power On-Off" label for the main power switch may cause a lack of awareness as to whether or not electrical power is being applied to the power distribution system. In addition, the area around the main power terminals is not marked with "CAUTION HIGH VOLTAGE, 120/208 VOLTS," and there is no protective cover over the lugs. A soldier could inadvertently come into contact with and suffer injury from terminals and cables under load. Finally, the emergency-stop control should be more clearly identified with bold letters indicating its function. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

b. The start pulley does not have a safety cover over it. A soldier could be seriously injured by either falling against the pulley or getting his clothing caught in it. This hazard is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

c. The two exhaust vents, one on each side of the generator, are directed toward the center of the trailer. Consequently, exhaust fumes are directed toward the operator when he tries to start up the second generator. If the generator is located in an area where there is little air circulation, the concentration of exhaust gases could cause the operator to become ill. Directing the exhaust gases upwards and outwards would correct this problem. This situation is classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

d. The generator is small enough to be moved manually. It exceeds the weight design limits (50 pounds) specified in MIL-STD-1472C for a single male soldier lifting an item four feet in the air; consequently, the generator should have its weight listed as part of a CAUTION label. The warning should be conspicuously placed on the generator to help prevent injury to personnel. The labeling problem is classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

e. The surface on the trailer floor is not slip-resistant. Thus, a soldier standing on it could easily slip and fall if it were wet from rain, fuel, oil, or water/coolant. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

f. Sound levels near the generator exceed 85 dB(A), the upper limit for steady state noise specified in MIL-STD-1474B(MI). Hearing protection is required for soldiers working close to this generator and CAUTION signs stating the requirement should be posted on the generator. This problem is classified as Category III, Marginal with respect to hazard severity and as Level D, Remote with respect to hazard probability.

7.1.3.5 Manufacturer C, 3 kW, 60 Hz Generator

7.1.3.5.1 System Safety Checklist

- a. The dc power connections on the battery are not color-coded.
- b. The area around the main power terminals is not marked with a "CAUTION HIGH VOLTAGE, 120/208 VOLTS" warning.
- c. The generator provides a main power switch which cuts off all power to the equipment; however, the switch is labeled "Circuit Breaker." It should be labeled "Main Power On-Off."
- d. The noise level at the operator's panel is not less than 85 dB(A); therefore, hearing protection is required for soldiers operating in the vicinity of the generator.
- e. The generator has sharp, overhanging edges which may cause injury to personnel. Covers are needed for the bolt ends that hold the brace on the battery.
- f. This generator weighs over 35 lbs; therefore, it should be labeled to indicate lifting requirements.
- g. The generator has not been designed to preclude the accidental ignition of hazardous atmospheres. The fuel fill is on top of the generator; therefore, spillage will run all over the unit.
- h. Ground rods and straps are not provided.
- i. The generators were mounted on a trailer that does not have non-slip characteristics.

7.1.3.5.2 Ratings Made By One Operator

The operator rated all items on the safety questionnaire as "Was Not In A Position To Say."

7.1.3.5.3 Comments Made By One Operator

The operator made no comments concerning the safety features of this generator.

7.1.3.5.4 Sound Level Measurements

These measurements were taken in the field in conjunction with an infrared photographic test. No load was on the system.

With Throttle In "Off" Position:

<u>Location of Measurement</u>	<u>dB(A) at one foot</u>	<u>Distance From Generator to 85 dB(A) Contour</u>
Operator's panel	96	4 ft. 0 in.
Side to right of operator's panel	96	6 ft. 4 in.
Side opposite to operator's panel	98	4 ft. 1 in.
Side to left of operator's panel	95	5 ft. 9 in.

With Throttle In "Auto" Position:

<u>Location of Measurement</u>	<u>dB(A) at one foot</u>	<u>Distance From Generator to 85 dB(A) Contour</u>
Operator's panel	88	2 ft. 3 in.
Side to right of operator's panel	86	2 ft. 7 in.
Side opposite to operator's panel	85	2 ft. 2 in.
Side to left of operator's panel	87	2 ft. 4 in.

7.1.3.5.5 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows:

a. The lack of color coding on the dc power connections for the battery could cause an operator to connect cables to the wrong terminals. The situation creates a safety hazard. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

b. The lack of a "Main Power ON-Off" label on the main power switch and the absence of a "CAUTION HIGH VOLTAGE, 120/208 VOLTS" sign near the terminals may cause a lack of awareness as to whether or not electrical power is being applied to the power distribution system. A soldier could inadvertently come into contact with and suffer injury from terminals or cables under load. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

c. Sound levels near the generator exceed 85 dB(A), the upper limit for steady state noise specified in MIL-STD-1474B(MI). Hearing protection and a "CAUTION HIGH NOISE LEVEL" sign are required. This problem is classified as Category III, Marginal with respect to hazard severity and as Level D, Remote with respect to hazard probability.

d. A soldier who fell against the generator could possibly receive lacerations from the bolts protruding from the battery rack. The bolt ends should be covered with protective caps. This problem is classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

e. The operator's manual indicates that the generator weighs over 160 lbs. The lifting requirements in MIL-STD-1472C specify 170 pounds as the design limit for two men lifting an item one foot in the air. It is recommended that "CAUTION: Unit Weighs XXX lbs" be stenciled on the generator, since two men will probably attempt to lift this small generator. This problem is classified as Category II, Critical with respect to hazard severity and as Level B, Reasonably Probable with respect to hazard probability.

f. The fuel fill is on the top of the generator. Spilled fuel will accumulate on the top and run down its sides, creating a fire hazard if a hot generator is being refueled. This safety problem is classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

g. Ground rods and straps were not provided with the generator, but had to be obtained by the operators through other sources. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

h. The surfaces on the trailer floor are not slip-resistant. A soldier standing on them could easily slip and fall if they were wet from rain, dew, fuel, water, or oil. This is categorized as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

7.1.3.6 Manufacturer D, 3 kW, 60 Hz Generator

7.1.3.6.1 System Safety Checklist

- a. There is no green indicator light to indicate when power is on.
- b. The area around the main power terminals is not marked with a "CAUTION HIGH VOLTAGE, 120/208 VOLTS" warning.
- c. The main power switch is not labeled as "Main Power On-Off."
- d. The main power switch is not readily accessible; panel doors must be removed before the switch can be accessed.
- e. The power connections to the batteries are not color-coded.
- f. Lifting rings or handles are not present for moving the generator.

7.1.3.6.2 Ratings Made By Operators

This generator was not used on the field exercises during the test. Consequently, there were no operators who had experience using it and thus no operator ratings are available for it.

7.1.3.6.3 Comments Made By Operators

None.

7.1.3.6.4 Sound Level Measurements

These measurements were taken in the field in conjunction with an infrared photographic test. No load was on the system.

<u>Location of Measurement</u>	<u>dB(A) at one foot</u>	<u>Distance From Generator to 85 dB(A) Contour</u>
Operator's panel	86	1 ft. 4 in.
Side to right of operator's panel	92	2 ft. 4 in.
Side opposite to operator's panel	87	1 ft. 11 in.
Side to left of operator's panel	93	3 ft. 10 in.

7.1.3.6.5 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows:

- a. The lack of a "Main Power On-Off" label on the main power switch, the lack of a green indicator light to indicate when power is on, and the inaccessibility of the main power switch may cause a lack of awareness as to whether or not electrical power is being applied to the power distribution system. In addition, there is no "CAUTION HIGH VOLTAGE" warning near the main power terminals. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

b. The lack of color coding on the dc power connections for the battery could cause an operator to connect cables to the wrong terminals, creating a situation conducive to arcing and explosion. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

c. The lack of lifting rings for moving the generator could result in damage to the generator frame if a sling were incorrectly placed around it to remove it from a trailer. This problem is classified as Category III, Marginal with respect to hazard severity and as Level D, Remote with respect to hazard probability.

d. Sound levels near the generator exceed 85 dB(A), the upper limit for steady state noise specified in MIL-STD-1474B(MI). Hearing protection and a "CAUTION HIGH NOISE LEVEL" warning are required. This problem is classified as Category III, Marginal with respect to hazard severity and as Level D, Remote with respect to hazard probability.

7.1.3.7 Manufacturer C, 5 kW, 60 Hz Generator

7.1.3.7.1 System Safety Checklist

- a. The area around the main power terminals is not marked with a "CAUTION HIGH VOLTAGE, 120/208 VOLTS" warning.
- b. The main power switch is labeled "Circuit Breaker" rather than "Main Power ON-Off."
- c. There are no eyehooks or handles for moving the generator.
- d. The fuel fill is on top of the generator. If fuel is spilled during refueling, it runs down the sides of the generator and poses a fire hazard.
- e. The floor surface of the trailer does not have non-slip characteristics.

7.1.3.7.2 Ratings Made By Eleven Operators

The tabulation of operators' responses to the safety questionnaire is shown below.

Table 7-5. Number of operators checking each category in the safety questionnaire (Manufacturer C, 5 kW, 60 Hz Generator)

	I Have Experienced	I Have Not Experienced But Is A Problem	Not A Problem	Was Not In A Position To Say
<u>Safety Incident</u>				
a. Electrical Shock	—	1	10	—
b. Fire or Fire Hazard*	1	—	2	—
c. Burns	—	1	9	1
d. Cuts, Scrapes, or Punctures	—	—	11	—
e. Extreme Temperature	1	—	10	—
f. Extreme Brightness	—	—	11	—
g. Extreme Loudness	—	—	11	—
h. Noxious Fumes	1	—	10	—

*The "Fire or Fire Hazard" category was added to the questionnaire after it had been administered to operators who participated in the Ft. Huachuca exercise.

7.1.3.7.3 Comments Made By Eleven Operators

- a. One operator commented: Electrical shock is possible around the load terminals on the generator. A better cover is needed.
- b. One operator commented: We did not ground the generator properly once. We could measure 50 volts case to ground, but I never got shocked.
- c. One operator commented: At one site we overloaded the generator; we were pulling 108 amps for three days, but the generator was made to produce only 75 amps. It caught on fire and burned up. That is why I indicated on the questionnaire that fire and fume hazards exist.
- d. One operator commented: The exhaust pipe gets hot, but you just have to be careful around it.
- e. One operator commented: I came close to being burned from the exhaust on the front generator once when I leaned over to look at the operator's panel on the rear generator.
- f. One operator commented: The generator got very warm after running for several days. But normally we would switch them every ten hours.

7.1.3.7.4 Sound Level Measurement

These sound level measurements were taken in the field in conjunction with an infrared photographic test. No load was on the system. The first set of measurements was taken when the throttle switch was in the "auto" position; the second set when it was in the "off" position.

<u>Location of Measurement</u>	<u>dB(A) at one foot</u>
Operator's panel	73/81
Side to right of operator's panel	74/81
Side opposite to operator's panel	75/83
Side to left of operator's panel	75/82

7.1.3.7.5 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows:

- a. The plate covering the load terminals on the front of the generator does not adequately protect individuals from inadvertently touching the terminals. In addition, the terminal area is not adequately marked with a caution sign warning against high voltage. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level D, Remote with respect to hazard probability.
- b. The main power switch should be labeled "Main Power On-Off" rather than "Circuit Breaker" so that it is apparent how to cut off power from the system in an emergency. This problem is categorized as Category I, Catastrophic and as Level D, Remote.

c. The exhaust pipe on the rear of the generator becomes hot and is readily accessible. A soldier who does not realize that the generator has been recently shut down could be burned by inadvertently touching the exhaust pipe. This problem is classified as Category III, Marginal and as Level C, Occasional.

d. The fuel fill is on the top of the generator, so the operator must climb up on the trailer to refuel the generator. He has to hold the fuel can in a position that is interferred with by the canvas supports, so fuel spillage is likely. The spilled fuel can run over the top and down the sides of the generator. This poses a fire hazard if a hot generator is being refueled. This safety problem is classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

e. The lack of eyehooks or handles for lifting the generator could result in damage to the generator frame if a sling were incorrectly placed around it to remove it from a trailer. This problem is classified as Category III, Marginal with respect to hazard severity and as Level D, Remote with respect to hazard probability.

f. The lack of a non-slip surface on the trailer floor could lead to an injury to a soldier if he slipped on the floor when it was wet from rain, spilled fuel, or spilled oil. A slippery floor is likely to occur because it is extremely difficult to refuel without spilling fuel and to check/drain the oil without spilling oil on the trailer floor. This problem is classified as Category II, Critical with respect to hazard severity and as Level B, Reasonably Probable with respect to hazard probability.

7.1.3.8 Manufacturer D, 5 kW, 60 Hz Generator

7.1.3.8.1 System Safety Checklist

- a. There is no green indicator light to indicate when power is on.
- b. There are no protective covers over the battery terminals.
- c. The area around the main power terminals is not marked with a "CAUTION HIGH VOLTAGE, 120/208 VOLTS" warning.
- d. The main power switch is not labeled as "Main Power On-Off."
- e. The main power switch is not readily accessible; panel doors must be removed before the switch can be accessed.
- f. Exhaust gases are vented at chest level at rear of generator.
- g. No eyehooks or handles are present for moving the generator.
- h. Refueling occurs inside the housing where spilled fuel can accumulate around a hot engine.

7.1.3.8.2 Ratings Made By Eight Operators

The tabulation of operators' responses to the safety questionnaire is shown below.

Table 7-6. Number of operators checking each category in the safety questionnaire (Manufacturer D, 5 kW, 60 Hz Generator)

	I Have Experienced	I Have Not Experienced But Is A Problem	Not A Problem	Was Not In A Position To Say
<u>Safety Incident</u>				
a. Electrical Shock	—	—	7	1
b. Fire or Fire Hazard*	—	—	3	—
c. Burns	—	—	7	1
d. Cuts, Scrapes, or Punctures	1	—	6	1
e. Extreme Temperature	—	1	7	—
f. Extreme Brightness	1	—	7	—
g. Extreme Loudness	1	—	7	—
h. Noxious Fumes	3	—	5	—
i. Other (specify)				
<u>Unsafe exhaust location</u>	—	1	—	—

*The "Fire or Fire Hazard" category was added to the questionnaire after it had been administered to operators who participated in the Ft. Huachuca exercise.

7.1.3.8.3 Comments Made By Eight Operators

- One operator commented: You sometimes scrape your knuckles when checking the oil.
- One operator commented: The generator is loud when the doors are off for maintenance.
- One operator commented: Diesels are hard to start in cold weather.
- One operator commented: The exhaust pipe is too high. If you walk by it, you get a face full of fumes. Also, hot engine gases damage the canvas on the trailer.

7.1.3.8.4 Sound Level Measurements

These measurements were taken in the field in conjunction with an infrared photographic test. No load was on the system.

<u>Location of Measurement</u>	<u>dB(A) at one foot</u>
Operator's panel	75
Side to right of operator's panel	80
Side opposite to operator's panel	75
Side to left of operator's panel	81

7.1.3.8.5 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows.

a. The lack of a "Main Power On-Off" label on the main power switch, the lack of a green indicator light to indicate when power is on, and the inaccessibility of the main power switch may cause a lack of awareness as to whether or not electrical power is being applied to the power distribution system. In addition, there is no "CAUTION HIGH VOLTAGE" warning near the main power terminals. These problems are classified as Category I, Catastrophic with respect to hazard severity and Level C, Occasional with respect to hazard probability.

b. The battery terminals lack protective covers. Thus, careless actions could result in shorting to the housing. This is classified as Category III, Marginal and as Level C, Occasional.

c. Exhaust gases are vented directly out of the rear of the generator at chest or head level. Thus, the generator blows hot fumes into the faces of soldiers passing by. This problem is classified as Category III, Marginal with respect to hazard severity and as Level B, Reasonably Probable with respect to hazard probability.

d. The lack of eyehooks or handles for lifting the generator could result in damage to the generator frame if a sling were incorrectly placed around it to remove it from a trailer. This problem is classified as Category III, Marginal with respect to hazard severity and as Level D, Remote with respect to hazard probability.

e. Refueling occurs inside the housing, so spilled fuel can accumulate around the hot engine and pose a fire hazard. This problem is classified as Category I, Catastrophic with respect to hazard severity and as Level D, Remote with respect to hazard probability.

f. The generator is quite loud when the doors are taken off. However, the sound level was not measured under this condition.

7.1.3.9 Manufacturer E, 5 kW, 60 Hz Generators

7.1.3.9.1 System Safety Checklist

- a. There is no green indicator light to indicate when power is on.
- b. The main power switch is located just above the terminal lugs. Operators could accidentally contact the lugs when operating the switch.
- c. The face plate covering the terminal lugs has a "DANGER HIGH VOLTAGE" warning printed in red letters. This warning does not conform to MIL-STD-454 and ANSI Z35.1-1972.
- d. The main power switch is not labeled as "Main Power On-Off".
- e. The housing surrounding the generator has no latches, locks, or other means for securing it when the housing is in the upright position.
- f. The fuel fill is located under the housing and is somewhat difficult to access with a five-gallon can. This could result in fuel spillage around the base of the generator.
- g. The edges and corners around the housing have not been rounded.
- h. The ground stud is not identified on the trailer.
- i. The floor surface of the trailer in front of each operator's panel does not have non-slip characteristics.

7.1.3.9.2 Ratings Made By Eight Operators

The tabulation of operators' responses to the safety questionnaire is shown below.

Table 7-7. Number of operators checking each category in the safety questionnaire (Manufacturer E, 5 kW, 60 Hz Generator)

	I Have Experienced	I Have Not Experienced But Is A Problem	Not A Problem	Was Not In A Position To Say
<u>Safety Incident</u>				
a. Electrical Shock	<u>1</u>	<u>2</u>	<u>4</u>	<u>1</u>
b. Fire or Fire Hazard	<u>—</u>	<u>2</u>	<u>5</u>	<u>1</u>
c. Burns	<u>—</u>	<u>2</u>	<u>5</u>	<u>1</u>
d. Cuts, Scrapes, or Punctures	<u>—</u>	<u>2</u>	<u>5</u>	<u>1</u>
e. Extreme Temperature	<u>—</u>	<u>2</u>	<u>5</u>	<u>1</u>
f. Extreme Brightness	<u>—</u>	<u>1</u>	<u>6</u>	<u>1</u>
g. Extreme Loudness	<u>—</u>	<u>1</u>	<u>6</u>	<u>1</u>
h. Noxious Fumes	<u>—</u>	<u>2</u>	<u>5</u>	<u>1</u>

7.1.3.9.3 Comments Made By Eight Operators

a. One operator commented: I was shocked by the generator once. I was in the process of switching over one of the generators, and there were a couple of leads that were sitting off down by the voltage switch. I guess I was touching some metal and the leads at the same time. I did get a slight shock. It was a tingle. Just enough to make you jump a little bit.

b. One operator commented: Electrical shock would be a problem if it happened, but the system, as designed, is safe. There is no specific fire hazard.

c. Two operators commented: There are sharp edges on the cover that someone could get cut on.

d. One operator commented: There should be a warning near the radiator caps about possible pressure in the radiator after the engine has been running, even if it is cool enough to touch. People who are not used to working around vehicles might get burned if they pulled the cap and there was pressure inside.

7.1.3.9.4 Sound Level Measurements

These measurements were taken in the field in conjunction with an infrared photographic test. No load was on the system.

<u>Location of Measurement</u>	<u>dB(A) at one foot</u>	<u>Distance From Generator to 85 dB(A) Contour</u>
Operator's panel	95	3 ft. 5 in
Side to right of operator's panel	87	1 ft. 5 in
Side opposite to operator's panel	95	4 ft. 0 in
Side to left of operator's panel	87	1 ft. 10 in

7.1.3.9.5 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows:

a. The main power switch is located immediately above the terminal lugs. Although a face plate provides some protection from accidental contact with the lugs, there is no means of preventing an operator from inadvertently dropping his fingers down over the top of the face plate as he operates the switch. His fingers could come into contact with the lugs. This problem is categorized as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

b. The lack of a "Main Power On-Off" label on the main power switch and the lack of a green indicator light to indicate when power is on may cause a lack of awareness as to whether or not electrical power is being applied to the power distribution system. A soldier could inadvertently come into contact with and suffer injury from terminals and cables carrying a load. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

c. The warning label on the face plate that covers the power terminals does not conform to MIL-STD-454 and ANSI Z35.1-1972. For voltages in the range 70-500, the label should read, "CAUTION HIGH VOLTAGE, XXX VOLTS". The letters should be yellow gothic capitals on a black background and the numbers should be black on yellow. This problem is classified as Category III, Marginal and as Level D, Remote.

d. The ground stud on the trailer is not labeled. This oversight is classified as Category III, Marginal and as Level D, Remote.

e. The metal housing surrounding the generator has sharp edges and corners that could cause injury if personnel fall against them. This hazard occurs mainly when an operator is maintaining the generator with the housing in the raised position. This danger is classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

f. There is no provision for securing the housing in the upright position. While a soldier is performing maintenance on the generator, the housing could be inadvertently bumped and fall down on the soldier. Serious injury could result if the generator were operating at the time. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

g. The location of the fuel fill complicates the refueling process. It contributes to the spillage of fuel which constitutes a fire hazard. The fire hazard is classified as Category II, Critical with respect to hazard severity and as Level D, Remote with respect to hazard probability.

h. The lack of a non-slip surface on the trailer floor at the front of each generator could cause an individual to slip when the floor was wet from rain or spilled fuel. An injury could result. The hazard is classified as Category II, Critical with respect to hazard severity and as Level B, Reasonably Probable with respect to hazard probability.

i. Sound levels near the generator exceed 85 dB(A), the upper limit for steady state noise specified in MIL-STD-1474B(MI). Hearing protection is required for soldiers working close to this generator and caution signs stating the requirement should be posted on the generator. This problem is classified as Category III, Marginal with respect to hazard severity and as Level D, Remote with respect to hazard probability.

7.1.3.10 Manufacturer A, 10 kW, 60 Hz Generator, Modified

7.1.3.10.1 System Safety Checklist

- a. There is no green indicator light to indicate when power is on.
- b. The area around the main power terminals is not marked with a "CAUTION HIGH VOLTAGE, 120/208 VOLTS" warning.
- c. The main power switch is not labeled as "Main Power ON-OFF."
- d. The main power switch is located to the side of the front panel rather than on the front panel.
- e. There are sharp edges on the air outlet.
- f. The fuel fill is near the batteries.
- g. The floor surface of the trailer does not have non-slip characteristics.

7.1.3.10.2 Ratings Made By Five Operators

The tabulation of operators' responses to the safety questionnaire is shown below.

Table 7-8. Number of operators checking each category in the safety questionnaire (Manufacturer A, 10 kW, 60 Hz Generator, Modified)

	I Have Experienced	I Have Not Experienced But Is A Problem	Not A Problem	Was Not In A Position To Say
<u>Safety Incident</u>				
a. Electrical Shock	—	—	4	1
b. Fire or Fire Hazard*	—	—	—	—
c. Burns	—	—	4	1
d. Cuts, Scrapes, or Punctures	—	—	4	1
e. Extreme Temperature	—	—	4	1
f. Extreme Brightness	—	—	4	1
g. Extreme Loudness	—	—	4	1
h. Noxious Fumes	—	—	4	1

*The "Fire or Fire Hazard" category was added to the questionnaire after it had been administered to operators who participated in the Ft. Huachuca exercise.

7.1.3.10.3 Comments Made By Operators

No comments.

7.1.3.10.4 Sound Level Measurements

These measurements were taken in the field in conjunction with an infrared photographic test. No load was on the system.

<u>Location of Measurement</u>	<u>dB(A) at one foot</u>	<u>Distance From Generator to 85 dB(A) Contour</u>
Operator's panel	92	2 ft. 11 in.
Side to right of operator's panel	91	3 ft. 0 in.
Side opposite to operator's panel	92	5 ft. 0 in.
Side to left of operator's panel	91	3 ft. 4 in.

7.1.3.10.5 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows:

a. The lack of a "Main Power On-Off" label on the main power switch, the lack of a green indicator light to indicate when power is on, and the inaccessibility of the main power switch may cause a lack of awareness as to whether or not electrical power is being applied to the power distribution system. A soldier could inadvertently come into contact with and suffer injury from terminals or cables carrying a load. In addition, there is no "CAUTION HIGH VOLTAGE" warning near the area of the main power terminals. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

b. The metal housing surrounding the generator has sharp edges and corners that could cause injury if personnel fall against them. This danger is classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

c. The fuel fill is located close to the batteries and load terminals (which have no protective covers over them). If fuel is spilled in the area, it could possibly be ignited by a spark from either the battery or the load terminals. This hazard is classified as Category I, Catastrophic with respect to hazard severity and as Level D, Remote with respect to hazard probability.

d. The lack of a non-slip surface on the trailer floor at the front of each generator could cause an individual to slip when the floor is wet from rain or spilled fuel. An injury could result. The hazard is classified as Category II, Critical with respect to hazard severity and as Level B, Reasonably Probable with respect to hazard probability.

e. Sound levels near the generator exceed 85 dB(A), the upper limit for steady state noise specified in MIL-STD-1474B(MI). Hearing protection is required for individuals working close to this generator and caution signs stating the requirement should be posted on the generator. This problem is classified as Category III, Marginal with respect to hazard severity and as Level D, Remote with respect to hazard probability.

7.1.3.11 Manufacturer D, 10 kW, 60 Hz Generator

7.1.3.11.1 System Safety Checklist

- a. There is no green indicator light to indicate when power is on.
- b. The main power switch is not labeled as "Main Power On-Off".
- c. The main power switch is not readily accessible. Panel doors must be removed before the switch can be accessed.
- d. The area around the main power terminals is not marked with a "CAUTION HIGH VOLTAGE, 120/208 VOLTS" warning.
- e. The dc power connections on the battery are not color-coded.
- f. The floor surface of the trailer does not have non-slip characteristics.
- g. The fuel fill is inside the housing, so spilled fuel can accumulate around a hot engine.

7.1.3.11.2 Ratings Made By Six Operators

The tabulation of operators' responses to the safety questionnaire is shown below.

Table 7-9. Number of operators checking each category in the safety questionnaire (Manufacturer D, 10 kW, 60 Hz Generator)

<u>Safety Incident</u>	I Have Experienced	I Have Not Experienced But Is A Problem	Not A Problem	Was Not In A Position To Say
a. Electrical Shock	—	1	4	1
b. Fire or Fire Hazard*	—	—	5	—
c. Burns	—	—	6	—
d. Cuts, Scrapes, or Punctures	1	—	5	—
e. Extreme Temperature	—	—	6	—
f. Extreme Brightness	—	—	6	—
g. Extreme Loudness	—	—	6	—
h. Noxious Fumes	1	—	5	—

*The "Fire or Fire Hazard" category was added to the questionnaire after it had been administered to operators who participated in the Ft. Huachuca exercise.

7.1.3.11.3 Comments Made By Six Operators

a. One operator commented: There is not enough of a gap between the lugs in the switch box. There is just a little bit more than a finger gap in there. Some of the power cables get mangled and beat up as you try to get them hooked up. In the past I have experienced a situation where the hot wire has shorted out against the cover. This becomes more of a problem with the bigger generators because these generators require several cables to be hooked up to each lug.

b. One operator commented: I was cut on the switch box once. There was a sharp edge on the cover for the lug area. We just taped some rubber stripping on it.

c. One operator commented: The exhaust blows straight out the back of the generator at the level of my maintenance shelters. I would prefer having an exhaust hose that directs the exhaust down to the ground.

7.1.3.11.4 Sound Level Measurements

These measurements were taken in the field on Golden Sabre XII. The generator was providing power to a series of communications maintenance vans.

<u>Location of Measurement</u>	<u>dB(A) at one foot</u>
Operator's panel	76
Side to right of operator's panel	80
Side opposite to operator's panel	76
Side to left of operator's panel	85

7.1.3.11.5 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows:

- a. The lack of a "Main Power On-Off" label on the main power switch, the lack of a green indicator light to indicate when power is on, and the inaccessibility of the main power switch may cause a lack of awareness as to whether or not electrical power is being applied to the power distribution system. A soldier could inadvertently come into contact with and suffer injury from terminals or cables carrying a load. In addition, there is no "CAUTION HIGH VOLTAGE" warning near the main power terminals. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.
- b. The battery cables and terminals are not color-coded. This could result in a mismatch between cables and terminals. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.
- c. The spacing between the lugs on the switch box is not adequate. Frequently, several cables must be connected to each lug and in order to get them to fit they must be twisted and bent. They eventually became frayed and damaged to the point where shorting becomes possible. This problem is classified as Category I, Catastrophic with respect to hazard severity and as Level D, Remote with respect to hazard probability.
- d. The edge of the cover on the switch box is sharp. One operator cut his hand on it. This problem is classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.
- e. The lack of a non-slip surface on the trailer floor could cause a soldier to slip when the floor was wet from rain, spilled oil, or spilled fuel. An injury could result. This problem is classified as Category II, Critical with respect to hazard severity and as Level B, Reasonably Probable with respect to hazard probability.

f. Exhaust gases are directed straight out of the rear of the generator at head level. Fumes blow on soldiers passing by and collect in shelters that are placed immediately behind the generator. A means for rerouting or redirecting the exhaust gases should be provided. This problem is classified as Category I, Catastrophic with respect to hazard severity and as Level D, Remote with respect to hazard probability.

g. Refueling occurs inside the acoustical housing. Spilled fuel can accumulate around the hot engine and pose a fire hazard. This problem is classified as Category I, Catastrophic with respect to hazard severity and as Level D, Remote with respect to hazard probability.

7.1.3.12 Manufacturer E, 10 kW, 60 Hz Generators

7.1.3.12.1 System Safety Checklist

- a. There is no green indicator light to indicate when power is on.
- b. The main power switch is located just above the terminal lugs. Operators could accidentally contact the lugs when they operate the switch.
- c. The face plate covering the terminal lugs has a "DANGER HIGH VOLTAGE" warning painted in red letters. This does not conform to MIL-STD-454 and ANSI Z35.1-1972 specifications.
- d. The main power switch is not labeled as "Main Power On-Off".
- e. The acoustical housing surrounding the generator has no latches, locks, or other means for securing it when the housing is in the upright position.
- f. The fuel fill is located under the housing and is somewhat difficult to access with a five-gallon can. This could result in fuel spillage around the base of the generator.
- g. The edges and corners around the housing have not been rounded.
- h. The ground stud is not identified on the trailer.
- i. The floor surface of the trailer does not have non-slip characteristics.

7.1.3.12.2 Ratings Made By Four Operators

The tabulation of operators' responses to the safety questionnaire is shown below.

Table 7-10. Number of operators checking each category in the safety questionnaire (Manufacturer E, 10 kW, 60 Hz Generator)

<u>Safety Incident</u>	I Have Experienced	I Have Not Experienced But Is A Problem	Not A Problem	Was Not In A Position To Say
a. Electrical Shock	<u>1</u>	—	<u>3</u>	—
b. Fire or Fire Hazard*	—	—	<u>3</u>	—
c. Burns	<u>1</u>	—	<u>3</u>	—
d. Cuts, Scrapes, or Punctures	—	—	<u>4</u>	—
e. Extreme Temperature	—	—	<u>4</u>	—
f. Extreme Brightness	—	—	<u>4</u>	—
g. Extreme Loudness	—	—	<u>4</u>	—
h. Noxious Fumes	—	—	<u>4</u>	—

*The "Fire or Fire Hazard" category was added to the questionnaire after it had been administered to operators who participated in the Ft. Huachuca exercise.

7.1.3.12.3 Comments Made By Four Operators

a. One operator commented: When I checked the fuel one night, I got shocked whenever I touched the generator or trailer. The next day we changed the grounding and the problem went away. I know we had the trailer grounded, but I am not sure we had the generator properly grounded. Now both are grounded.

b. One operator commented: The circuit breaker was right above the lug terminals, with only a small piece of plastic covering the lugs. If one wasn't watching what he was doing, he could easily touch the lug nuts while trying to get to the circuit breaker. He could get electrocuted. Also, the lugs are in a small area and are hard to work with. The same is true of the ground stud.

c. One operator commented: The lugs are located in a hazardous position. If one of the rods holding on the lug cover plate breaks off, the generator cover could easily hit the lugs as the cover is lowered. This could cause a short and could possibly hurt someone. The protective lid over the circuit breaker vibrated off once and shorted things out when it fell onto the load terminals. The load terminals need to be relocated.

d. One operator commented: If you are not careful you will hit the exhaust when checking the oil.

7.1.3.12.4 Sound Level Measurements

These measurements were taken in the field during Golden Sabre XII. The generator was under a load.

<u>Location of Measurement</u>	<u>dB(A) at one foot</u>	<u>Distance From Generator to 85 dB(A) Contour</u>
Operator's panel	91	2 ft. 0 in
Side to right of operator's panel	--	1 ft. 5 in
Side opposite to operator's panel	--	3 ft. 0 in
Side to left of operator's panel	85	1 ft. 0 in

7.1.3.12.5 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows:

a. The main power switch is located immediately above the terminal lugs. Although a face plate provides some protection from accidental contact with the lugs, there is no means of preventing an operator from inadvertently dropping his fingers down over the top of the face plate as he operates the switch. His fingers could come into contact with the lugs. Also, when the flexible cover for the generator is being placed back over the generator, one of its legs could possibly break the plastic cover plate over the lugs. The cover could come into contact with the load terminals. These problems are categorized as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

b. The lack of a label on the main power switch and the lack of a green indicator light to indicate when power is on may cause a lack of awareness as to whether or not electrical power is being applied to the power distribution system. An soldier could inadvertently come into contact with and suffer injury from terminals or cables carrying a load. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

c. The warning on the face plate that covers the power terminals does not conform to MIL-STD-454 and ANSI Z35.1-1972. For voltages in the range 70-500, the warning should read, "CAUTION HIGH VOLTAGE, XXX." The letters should be yellow gothic capitals on a black background and the numbers should be black on yellow. This problem is classified as Category III, Marginal and as Level D, Remote.

d. The ground stud on the trailer is not labeled. This oversight is classified as Category III, Marginal and as Level D, Remote.

e. The metal housing surrounding the generator has sharp edges and corners that could cause injury if personnel fall against them. This hazard occurs mainly when an operator is maintaining the generator with the housing in the raised position. This danger is classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

f. There is no provision for securing the housing in the upright position. While a soldier is performing maintenance on the generator, the housing could be inadvertently bumped and fall down on the soldier. Serious injury could result if the generator were operating at the time. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

g. The location of the fuel fill complicates the refueling process. It contributes to the spillage of fuel which constitutes a fire hazard. The fire hazard is classified as Category II, Critical with respect to hazard severity and as Level D, Remote with respect to hazard probability.

h. The lack of a non-slip surface on the trailer floor at the front of each generator could cause an individual to slip when the floor was wet from rain or spilled fuel. An injury could result. The hazard is classified as Category II, Critical with respect to hazard severity and as Level B, Reasonably Probable with respect to hazard probability.

i. Sound levels near the generator exceed 85 dB(A), the upper limit for steady state noise specified in MIL-STD-1474B(MI). Hearing protection is required for soldiers working close to this generator and caution signs stating the requirement should be posted on the generator. This problem is classified as Category III, Marginal with respect to hazard severity and as Level D, Remote with respect to hazard probability.

j. In order to reach the oil dipstick, the operator must reach down past the muffler. If the engine has been running, the muffler will be hot and an operator could inadvertently get burned by it. This problem is classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

7.1.3.13 Manufacturer A, 15 kW, 60 Hz Generator, Modified

7.1.3.13.1 System Safety Checklist

- a. The generator provides a yellow indicator light to indicate when power is on. The light should be green.
- b. The generator provides a main power switch which cuts off all power to the equipment, but the switch is labeled improperly. It is labeled "CKT BRK Close-Open"; it should be labeled "Main Power ON-OFF".
- c. Emergency controls are not clearly identified.
- d. Exposed belts do not have adequate safety covers. The lower parts of the belts are uncovered.
- e. The access doors, with their hinges and fasteners, were not designed to prevent injury to personnel. The doors are too heavy and too awkward to fold up and latch on top of the acoustical housing. If the doors were accidentally bumped while in the "opened" position, the doors could fall and injure a soldier.
- f. The noise levels at the operator's panel and around the vicinity of the generator are greater than 85 db(A); therefore, hearing protection is required for those who work around the generator.
- g. Sharp edges and corners have not been eliminated. The sharp edges on the step at the operator's panel may cause injury to personnel.
- h. Ground rods and straps were provided, but the brass ground rods are too weak to go into hard ground.
- i. Indicator lights are not properly color-coded; i.e., they are all red lights.
- j. The exhaust area shoots out a wide stream of air which is not easily constricted or vented.

7.1.3.13.2 Ratings Made By Three Operators

The tabulation of operators' responses to the safety questionnaire is shown below.

Table 7-11. Number of operators checking each category in the safety questionnaire (Manufacturer A, 15 kW, 60 Hz Generator, Modified)

	I Have Experienced	I Have Not Experienced But Is A Problem	Not A Problem	Was Not In A Position To Say
<u>Safety Incident</u>				
a. Electrical Shock	—	—	1	2
b. Fire or Fire Hazard*	—	—	1	2
c. Burns	—	—	1	2
d. Cuts, Scrapes, or Punctures	—	—	1	2
e. Extreme Temperature	—	—	1	2
f. Extreme Brightness	—	—	1	2
g. Extreme Loudness	1	1	1	—
h. Noxious Fumes	—	—	1	2

*The "Fire or Fire Hazard" category was added to the questionnaire after it had been administered to operators who participated in the Ft. Huachuca exercise.

7.1.3.13.3 Comments Made By Three Operators

a. Three operators commented: The noise level with baffles and doors open is somewhat too high. There's not a lot you can do about it with the doors open. You have to check the oil while listening to the motor and the generator — it's too loud. Ear protection is still required.

b. One operator commented: The plastic panel mounted with 6 3/8' bolts restricts access to the lugs. You can't get your hands behind it, so you have to take the panel off. Some people are just going to leave it off--causing a safety hazard. If there were some way to mount it differently (say with nuts or some kind of device to quick-release the panel), it would be nice.

c. One operator commented: The Emergency Stop-Run switch is inadequate. It is a little circuit breaker button located right under the test lights. It's not marked and it's hard to see. If you needed to shut the generator down in a hurry, you'd never be able to find it. In addition, the circuit breaker button is hard to pull out.

d. One operator commented: The latches on the access doors are very inadequate. There's no way to tell how well the multiple-turn latches are latched because you can't feel any type of positive locking action on the doors. If you just had a small portion of the access panel latched, you wouldn't know it until the door came open. If this occurred during transit, or during operation, the generator could be damaged.

e. Two operators commented: There are no safety catches or locking mechanisms on the doors to hold them up securely when they are folded in the "opened" position. The present catch is unsafe because the doors could fall down due to the vibration of the generator. The doors could also fall down if they are inadvertently jarred loose from the latch on top. We solved the problem by having one person hold a door up while the operator worked on the generator. It would be helpful if there was a chain hook on either side to secure an opened door, or if the doors were redesigned so that they folded completely back, rested on top of the generator, and could be latched securely to the top.

7.1.3.13.4 Sound Level Measurements

These measurements were taken in the field during Golden Sabre XII. The generator was under a load.

<u>Location of Measurement</u>	<u>dB(A) at one foot</u>	<u>Distance From Generator to 85 dB(A) Contour</u>
Operator's panel	91	6 ft. 3 in.
Side to right of operator's panel	--	7 ft. 6 in.
Side opposite to operator's panel	--	6 ft. 4 in.
Side to left of operator's panel	--	7 ft. 3 in.

7.1.3.13.5 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows:

a. The "power on" indicator light is yellow, rather than green--as specified in MIL-STD-1472C. The lack of a "MAIN POWER ON-OFF" label on the main power switch may cause a lack of awareness as to whether or not electrical power is being applied to the power distribution system. In addition, the area around the main power terminals is not marked with a "CAUTION HIGH VOLTAGE, 120/208 VOLTS" warning. Thus, a soldier could inadvertently come into contact with and suffer injury from terminals or cables under load. Finally, the emergency-stop control should be more clearly identified with bold letters indicating its function. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

b. The fan and belt inside the housing are only partially covered with a protective guard. A soldier could inadvertently stick his hand into the fan blades or get his clothing caught in the belts and pulleys. This situation is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

c. The doors on the generator are held in the "opened" position by the overlap of a right-angle bracket on the door and a right-angle bracket on the top of the generator. If a soldier who is working on the generator stands up and inadvertently bumps the door with his shoulder or back, the door could come loose and fall down on him, causing personal injury. This is a problem because the doors are hinged in the middle and are difficult to control once they are released from the latched position. A lock mechanism that precludes unlatching by accidental contact would alleviate this problem. This hazard is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

d. The multiple-turn latches do not facilitate normal and emergency operations around the generator. The latches make it impossible to gain quick access to the generator and engine. Also, it is difficult to determine if the multiple-turn latches have secured the access doors. It is possible for a door to appear to be secured when it is actually loose. In this case, it could come loose during transit, causing damage to the housing on the generator. This situation is classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

e. Exhaust gases are vented through a large vent in the baffling rather than through an exhaust pipe. This precludes the easy use of an extension tube for shunting exhaust gases to the outside of an enclosed area (when the generator is used in such a configuration). Without the extension, there could be a build up of toxic fumes in the enclosed area. This problem is classified as Category I, Catastrophic with respect to hazard severity and as Level D, Remote with respect to hazard probability.

f. The step or landing at the operator's panel has sharp edges. A soldier could be injured if he fell or bumped against them, so the edges should be rounded. This problem is classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

g. The recessed position of the fuel fill contributes to frequent spillage of fuel during the refueling process. Although the fuel spillage remains outside the housing, it poses a fire hazard. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

h. It is difficult to connect cables to the lugs because there is not enough space between the lugs to easily insert and tighten down the cables. The cables must be twisted and bent to get them to fit. They can become frayed and damaged to the point that shorting is possible. This problem is classified as Category I, Catastrophic with respect to hazard severity and as Level D, Remote with respect to hazard probability.

i. Sound levels near the generator exceed 85 dB(A), the upper limit for steady state noise specified in MIL-STD-1474B(MI). Hearing protection and a "CAUTION, HIGH NOISE LEVEL" warning are required. This problem is classified as Category III, Marginal with respect to hazard severity and as Level D, Remote with respect to hazard probability.

7.1.3.14 Manufacturer B, 15 kW, 60 Hz Generator

7.1.3.14.1 System Safety Checklist

- a. The dc power connections on the battery are not color-coded.
- b. The terminal area is marked with a "DANGER 240 VOLTS" warning stenciled in red. TOP 6-2-507 recommends using a yellow stencil that says "CAUTION HIGH VOLTAGE, 120/208 VOLTS."
- c. The location of the main power switch does not prevent activation/de-activation of the generator by accidental contact. When the control panel door is open, there is no protection for the switch. A safety cover over the switch would prevent an operator from accidentally tripping it with his feet.
- d. Emergency controls are placed in a readily accessible location; however, the on-off positions of the main power switch should be reversed. With this change, the switch would conform to the generally-accepted operational design of a switch—i.e., an "up" movement to turn a switch on and a "down" movement to turn it off.
- e. Fans and belts do not have adequate safety covers. The present cover should be rotated 90°.
- f. The door on top of the generator was not designed to prevent injury to personnel. It is extremely heavy and could easily slam on an operator's hands or head. A hydraulic or spring-loaded support is needed to prevent rapid movement of the door.
- g. Parts and components are not free from the potential for releasing explosive fumes or vapors, i.e., the fuel fill is too close to the battery. It is right above the battery and should be moved to a safer location.
- h. With the present ventilation system, cooling air and exhaust gases cannot be vented away from confined areas.
- i. Sharp edges and corners have not been eliminated.
- j. Fueling and refueling operations cannot be conducted in a manner that precludes accidental ignition of fuel. The fuel fill is directly above the battery. It should be relocated to a safer place.
- k. Safety chains are not provided to prevent the generator/trailer from breaking away and becoming completely detached from the towing vehicle.
- l. Ground rods and straps are not provided.
- m. Indicator lights are not properly color-coded. For example, the "Fuel Pump On" indicator is red. Also, the red lights on the power distribution box cannot be detected in bright sunlight.
- n. The walking surfaces on the side fenders do not provide adequate non-slip characteristics. The back step does provide these characteristics, however.

o. Fire hazards have not been kept to a minimum--i.e., the fuel fill is above the battery compartment.

p. The door on top has a support with a positive lock for the "opened" position; however, the door (when opened and locked) is hard to unlock and close safely because the door is very heavy.

q. The routing of exhaust gases does not prevent the concentration of carbon monoxide at the operator's panel. These gases are exhausted at the rear of the unit where the operator's panel is located.

r. The plate over the load terminals on the power distribution box does not allow enough clearance to get the cables in and out easily.

7.1.3.14.2 Ratings Made By Four Operators

The tabulation of operators' responses to the safety questionnaire is shown below.

Table 7-12. Number of operators checking each category in the safety questionnaire (Manufacturer B, 15 kW, 60 Hz Generator)

<u>Safety Incident</u>	I Have Experienced	I Have Not Experienced But Is A Problem	Not A Problem	Was Not In A Position To Say
a. Electrical Shock	—	—	2	2
b. Fire or Fire Hazard*	—	—	2	2
c. Burns	—	—	3	1
d. Cuts, Scrapes, or Punctures	—	—	3	1
e. Extreme Temperature	—	—	3	1
f. Extreme Brightness	—	1	3	—
g. Extreme Loudness	—	—	4	—
h. Noxious Fumes	—	1	3	—

*The "Fire or Fire Hazard" category was added to the questionnaire after it had been administered to operators who participated in the Ft. Huachuca exercise.

7.1.3.14.3 Comments Made By Four Operators

- a. One operator commented: The exhaust is right near the back where the operator's panel is. This causes a problem when you lift up the door on top, i.e., you end up sucking in any exhaust that comes out. When you are working around there, you are going to be breathing it in. It would be better to move the exhaust area so you could work in there without having to breathe the exhaust fumes.
- b. One operator commented: If you are over 6 feet tall and you stand upon the platform, the exhaust comes straight into your face. If the exhaust were re-routed, it would be perfect.
- c. One operator commented: When you have to climb up on the fenders to work on the generator, it is too narrow and unsafe. If the fenders were wet and you slipped, you would get hurt.
- d. One operator commented: The panel lights are too bright for conducting safe, tactical operations. There should be a way to dim or turn these lights off--especially the bright green Power-On light.
- e. One operator commented: The cover over the lugs should be a bit more water tight.
- f. Two operators commented: The fuel fill should be relocated. It is too close to the batteries and too high on the generator. If it were located at trailer level on the front of the acoustical box (i.e., right above the trailer tongue), the operator could rest heavy fuel cans on the trailer while he filled the generator. This modification would reduce spillage and keep the fuel away from the batteries.
- g. One operator commented: The top door is hard to open and close. It is a safety hazard now.
- h. One operator commented: The power box on the trailer is very inadequate. It should be placed in a position so that the lugs are more accessible. The lugs should be larger and have greater spacing between them. Presently the power box is unsuitable for general use.

7.1.3.14.4 Sound Level Measurements

These measurements were taken in the field in conjunction with an infrared photographic test. No load was on the system.

<u>Location of Measurement</u>	<u>dB(A)</u> <u>at one foot</u>
Operator's panel	80
Side to right of operator's panel	74
Side opposite to operator's panel	77
Side to left of operator's panel	80

7.1.3.14.5 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows:

a. The lack of color coding for the dc power connections on the battery could cause an operator to connect cables to the wrong terminals. The situation creates a safety hazard. This problem is classified as Category II, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

b. The main power switch is located at foot-level and could be inadvertently bumped to the "on" position by an operator. (A guard over this switch would prevent such an accident.) In addition, the "off" position of the switch is up, rather than down, as is standard in the United States. A soldier may inadvertently put a load on the system and may come into contact with live terminals thought to be dead. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

c. There is insufficient room in the switch box on the trailer to hook up several cables and then replace the safety cover over the lugs. Consequently, the safety cover will be left off frequently and live terminal lugs will remain exposed. A soldier could be shocked. This problem is classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

d. The guard around the fan and belt should be rotated 90° to prevent an operator's hands or clothing from being caught in them inadvertently. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

e. The hinged door on the top of the generator is heavy and difficult to control when it is lowered into the "closed" position. A hydraulic support or some other mechanism is needed to put upward resistance on the door. This would prevent it from slamming on an operator's hands when he closes it. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

f. The fuel fill is located near the batteries. This poses a fire hazard since fuel spillage can accumulate near the batteries. This problem is classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

g. Exhaust gases are vented next to the operator's control panel; consequently, operators must breathe exhaust fumes when working at the panel. This could make some operators ill, especially if the generator were located in an area where there was little air movement. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

h. The housing surrounding the generator has sharp edges and corners. A soldier could be injured if he fell or bumped against them, so the edges and corners should be rounded. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

i. There are no safety chains on the trailer to prevent the trailer from becoming detached from a tow vehicle if the main towing mechanism breaks. This problem is classified as Category I, Catastrophic with respect to hazard severity and as Level D, Remote with respect to hazard probability.

j. Ground rods and straps were not provided with the generator. The operators had to obtain them through other sources. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

k. The "Fuel Pump On" and "Power On" indicator lights are red, rather than green as MIL-STD-1472C specifies for "function activated" and "power on" conditions. The color red should be reserved for "malfunction" conditions that need immediate attention. Also, the "on" condition of the indicator light on the switch box does not show up well in bright sunlight. A more intense light should be used to indicate when power is on. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

l. The surfaces on the trailer fenders do not have non-slip characteristics. A soldier standing on them could slip and fall easily if the surfaces were wet from rain. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

7.1.3.15 Manufacturer F, 15 kW, 60 Hz Generator

7.1.3.15.1 System Safety Checklist

- a. The dc power connections on the battery are not color-coded. Also, there are no rubber boots on the battery terminals.
- b. The area around the main power terminals is not marked with a "CAUTION HIGH VOLTAGE, 120/208 VOLTS" warning.
- c. The main power switch is not clearly identified. It is labeled as "Gen. OFF Line", rather than "Main Power ON-Off".
- d. There are no emergency controls.
- e. The fan and fan belt have no safety guards.
- f. The access doors were not designed to prevent injury to personnel. When the doors are opened, they are free to move on their own. There are no fasteners or latches to secure the doors while they are open.
- g. There are no hooks on the safety chains; however, there is an emergency wheel lock for the trailer wheels -- to be used if the trailer breaks away from the truck.
- h. Ground rods and straps were not provided.

7.1.3.15.2 Ratings Made By Four Operators

The tabulation of operators' responses to the safety questionnaire is shown below.

Table 7-13. Number of operators checking each category in the safety questionnaire (Manufacturer F, 15 kW, 60 Hz Generator)

	I Have Experienced	I Have Not Experienced But Is A Problem	Not A Problem	Was Not In A Position To Say
<u>Safety Incident</u>				
a. Electrical Shock	—	—	4	—
b. Fire or Fire Hazard*	—	—	4	—
c. Burns	—	—	4	—
d. Cuts, Scrapes, or Punctures	—	—	4	—
e. Extreme Temperature	—	—	4	—
f. Extreme Brightness	—	—	4	—
g. Extreme Loudness	—	—	4	—
h. Noxious Fumes	—	—	4	—

*The "Fire or Fire Hazard" category was added to the questionnaire after it had been administered to operators who participated in the Ft. Huachuca exercise.

7.1.3.15.3 Comments Made By Four Operators

- One operator commented: The hook-up mechanism and landing legs are not sturdy enough for movement on road maneuvers. The generators should be mounted on mil std trailers.
- Two operators commented: The lugs are not large enough for safe and convenient operation.
- One operator commented: The brakes on the trailer locked up when a driver tried to back up. The design features for the brakes should be re-thought.
- One operator commented: The brake system is inadequate. There are no air brakes, only one safety chain, and cheap safety features.
- One operator commented: The protective cover over the lug area should be more secure, harder to get into, and should have something to lock it down.

f. Two operators commented: The trailer is too low to the ground. Since the fuel tank is on the bottom of the trailer, you have to worry about puncturing the tank when traveling cross-country. If it were mounted a little higher, it would work a lot better and be a lot safer.

g. One operator commented: You should move the power box to the side of the acoustical enclosure because a person could bump up against the lugs while he was standing at the operator's panel. For safety reasons, put the power box on the side or move it down. Also, put a better cover over the lugs.

7.1.3.15.4 Sound Level Measurements

These measurements were taken in the field in conjunction with an infrared photographic test. No load was on the system.

<u>Location of Measurement</u>	<u>dB(A)</u> <u>at one foot</u>
Operator's panel	71
Side to right of operator's panel	74
Side opposite to operator's panel	79
Side to left of operator's panel	79

7.1.3.15.5 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows:

a. The lack of color coding for the dc power connections on the battery could cause an operator to connect cables to the wrong terminals. The situation creates a safety hazard. In addition, the lack of rubber protectors over the cable-terminal connections permits accidental shorting from a terminal to other components. These problems are classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

b. The lack of a "Main Power ON-Off" label for the main power switch may cause a lack of awareness as to whether or not electrical power is being applied to the power distribution system. In addition, the area around the power connections is not marked with a "CAUTION HIGH VOLTAGE, 120/208 VOLTS" warning. A soldier could inadvertently come into contact with and suffer injury from terminals or cables under load. Also, the flexible cover over the lug area is not sufficient to keep soldiers from inadvertently sticking their hands on the lugs. This especially exists when several cables are connected to the lugs, because the cover cannot be snapped down over the lugs. The problem is compounded by having the terminal area located directly below the operator's panel. Another problem is that the lugs are smaller than the standard lugs on Army 15 kW generators. It is difficult to connect the size and number of cables that the Army uses sometimes. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

c. The fan and belt inside the housing are not covered with a protective guard. A soldier could be injured if he inadvertently stuck his hand into the fan blades or got his clothing caught in the belts and pulleys. This situation is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

d. The doors to the housing do not have a positive locking mechanism to keep them in the "opened" position. They can swing freely and can be caught easily by the wind and blown against a soldier as he works on the generator, causing personal injury. This problem is classified as Category III, Marginal with respect to hazard severity and as Level B, Reasonably Probable with respect to hazard probability.

e. The safety chains on the trailer do not have hooks on them, so they cannot be adequately utilized to keep the trailer attached to the towing vehicle if the main towing mechanism breaks. This problem is classified as Category I, Catastrophic with respect to hazard severity and as Level D, Remote with respect to hazard probability.

f. Ground rods and straps are not provided with the generator; therefore, operators must obtain them from other sources. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

g. The fuel tank is too low to the ground. If it were punctured while the generator was being towed cross-country, a fire could occur. The hazard is classified as Category II, Critical with respect to hazard severity and as Level D, Remote with respect to hazard probability.

7.1.3.16 Manufacturer A, 30 kW, 60 Hz Generator, Modified with Baffling on
Doors and Exhaust System

7.1.3.16.1 System Safety Checklist

- a. There is no green indicator light to indicate when power is on.
- b. The area around the main power terminals is not marked with a "CAUTION HIGH VOLTAGE, 120/208 VOLTS" warning.
- c. The generator provides a main power switch which cuts off all power to the equipment; however, the switch is labeled "CKT BRK--Close, Open." It should be labeled "Main Power On-Off."
- d. The location of the main power switch does not preclude activation of equipment by accidental contact.
- e. Exposed belts do not have adequate safety covers. A safety guard was attempted but it is not sufficient.
- f. The access doors have not been designed to prevent accidental injury to personnel. When the doors are folded in the "opened" position, they can be bumped and dislodged from their gravity-type latches. It is possible for them to fall down on the operator or any other person standing near the generator. The doors need positive locks to secure them in the "opened" position.
- g. Cooling air and exhaust gases are not ducted or vented away from confined areas. Exhaust gases are not blown away from the operator; the exhaust pipe is angled so that the exhaust blows on personnel as they walk by the generator.
- h. The noise level at the operator's panel is not less than 85 dB(A); therefore, hearing protection is required for personnel working in the immediate vicinity of the generator.
- i. Sharp edges on the back of operator panel doors and on the operator's step may cause injury to personnel.
- j. Ground rods and straps were not provided with the unit.
- k. Indicator lights are not properly color-coded. A yellow light is associated with the main power switch; all other lights are red.
- l. The battery terminals are not covered with rubber boots.

7.1.3.16.2 Ratings Made By Three Operators

The tabulation of operators' responses to the safety questionnaire is shown below.

Table 7-14. Number of operators checking each category in the safety questionnaire (Manufacturer A, 30 kW, 60 Hz Generator, Modified with Baffling on Doors and Exhaust System)

<u>Safety Incident</u>	I Have Experienced	I Have Not Experienced But Is A Problem	Not A Problem	Was Not In A Position To Say
a. Electrical Shock	—	1	1	1
b. Fire or Fire Hazard*	—	—	2	1
c. Burns	—	—	2	1
d. Cuts, Scrapes, or Punctures	—	—	2	1
e. Extreme Temperature	—	—	3	—
f. Extreme Brightness	—	—	3	—
g. Extreme Loudness	—	—	3	—
h. Noxious Fumes	—	—	2	1

*The "Fire or Fire Hazard" category was added to the questionnaire after it had been administered to operators who participated in the Ft. Huachuca exercise.

7.1.3.16.3 Comments Made By Three Operators

- Two operators commented: The noise levels with baffles and doors closed and open are somewhat too high. The generator is somewhat quieter than the others, but it's still too noisy. If you're hiding out from someone in a tactical situation, they'd be able to hear the generator.
- One operator commented: The vibration level is somewhat too high. It shakes me all around when I'm standing on it.
- One operator commented: The access doors will not remain open when they are folded and latched to the top of the generator. The doors should be redesigned.

7.1.3.16.4 Sound Level Measurements

These measurements were taken in the field during Golden Sabre XII. No load was on the system.

<u>Location of Measurement</u>	<u>dB(A) at one foot</u>	<u>Distance From Generator to 85 dB(A) Contour</u>
Operator's panel	99	11 ft. 0 in.
Side to right of operator's panel	98	10 ft. 0 in.
Side opposite to operator's panel	95	6 ft. 8 in.
Side to left of operator's panel	102	12 ft. 8 in.

7.1.3.16.5 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows:

a. The "power on" indicator light is yellow rather than green--as specified in MIL-STD-1472C. The main power switch is labeled "CKT BRK Close-Open"; it should be labeled "Main Power On-Off." The present label may cause a lack of awareness as to whether or not electrical power is being applied to the power distribution system. In addition, the area around the main power terminals is not marked with a "CAUTION HIGH VOLTAGE, 120/208 VOLTS" warning. Thus, a soldier could inadvertently come into contact with and suffer injury from terminals or cables under load. Finally, the emergency-stop control should be more clearly identified with bold letters indicating its function. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

b. The fan and belt inside the housing are only partially covered with a protective guard. A soldier could inadvertently stick his hand into the fan blades or get his clothing caught in the belts and pulleys. This situation is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

c. The doors on the generator are held in the "opened" position by the overlap of a right-angle bracket on the door and a right-angle bracket on the top of the generator. The doors will not stay open in this position. Also, if a soldier who is working on the generator stands up and inadvertently bumps the door with his shoulder or back, the door could come loose and fall down on him, causing personal injury. This is a problem because the doors are hinged in the middle and are difficult to control once they are released from the latched position. A lock mechanism that precludes unlatching by accidental contact would alleviate this problem. This hazard is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

d. Exhaust gases are vented through the front of the generator. Hot fumes are blown into the faces of soldiers who are near it. This problem is classified as Category II, Critical with respect to hazard severity and as Level D, Remote with respect to hazard probability.

e. The step or landing at the operator's panel and the operator's panel door have sharp edges. A soldier could be injured if he fell or bumped against them, so the edges should be rounded. This problem is classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

f. Ground rods and straps are not provided with the generator; therefore, operators must obtain them from other sources. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

g. The lack of color-coding for the dc power connections on the battery could cause an operator to connect cables to the wrong terminals. The situation creates a safety hazard that is conducive to arcing and explosion. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

h. Sound levels near the generator exceed 85 dB(A), the upper limit for steady state noise specified in MIL-STD-1474B(MI). Hearing protection and a "CAUTION, HIGH INTENSITY NOISE" warning are required [see Section 4.3, MIL-STD-1474B(MI)]. This problem is classified as Category III, Marginal with respect to hazard severity and as Level D, Remote with respect to hazard probability.

7.1.3.17 Manufacturer AW, 30 kW, 60 Hz Generator

7.1.3.17.1 System Safety Checklist

- a. There is no green indicator light to indicate when power is on.
- b. Operating personnel are not protected from accidental contact with voltages greater than 30 volts ac or dc. The generator needs a protective cover over the lugs.
- c. The area around the main power terminals is not marked with a "CAUTION HIGH VOLTAGE, 120/208 VOLTS" warning.
- d. The generator provides a main power switch which cuts off all power to the equipment; however, the switch is labeled "CKT BRK--Close, Open." It should be labeled "Main Power On-Off."
- e. Emergency controls are not clearly identified.
- f. Exposed belts do not have adequate safety covers.
- g. The trailer does not have a jack and the generator/trailer is too heavy to be lifted manually.
- h. The fender is too high on the trailer. It blocks getting the doors off and putting them back on. The whole set-up could cause the operator to pinch or scrape his hands and fingers while taking the doors off or putting them back on.
- i. Cooling air and exhaust gases are not ducted or vented away from confined areas. They are deflected down in a large area at the rear of the generator.
- j. Sharp edges and corners have not been eliminated.
- k. The generator was not designed so that the center of gravity makes the generator unlikely to tip over from imbalance or strong wind. The generator is too top heavy for the trailer; it could tip over very easily.
- l. The weight distribution is not such that the generator is easy to handle, move, or position.
- m. The tongue of the generator/trailer is too heavy to lift, so the trailer needs a crank.
- n. Ground rods and straps were not provided with the unit.
- o. Indicator lights are not properly color-coded.
- p. The fender of the trailer does not provide adequate non-slip characteristics.

q. Fire hazards have not been kept to a minimum. It is difficult to fit the fuel nozzle into the fuel fill because the recessed space is too small. Plus, the door over the fuel fill won't stay up. It creates a nuisance when the operator refuels the generator. The fuel fill door needs a positive lock to keep it in the "opened" position during refueling operations.

r. The routing of the exhaust pipe does not prevent a concentration of carbon monoxide around the generator. Exhaust gases are not constricted so they can be readily diverted through an extension pipe or tube to a safer location.

7.1.3.17.2 Ratings Made By Two Operators

The tabulation of operators' responses to the safety questionnaire is shown below.

Table 7-15. Number of operators checking each category in the safety questionnaire (Manufacturer AW, 30 kW, 60 Hz Generator)

	I Have Experienced	I Have Not Experienced But Is A Problem	Not A Problem	Was Not In A Position To Say
<u>Safety Incident</u>				
a. Electrical Shock	—	—	1	1
b. Fire or Fire Hazard*	—	—	1	1
c. Burns	—	—	1	1
d. Cuts, Scrapes, or Punctures	—	—	1	1
e. Extreme Temperature	—	—	1	1
f. Extreme Brightness	—	—	1	1
g. Extreme Loudness	—	—	1	1
h. Noxious Fumes	—	—	1	1
i. Other (specify)				
<u>Generator hook-up to trailer</u>				
	—	1	—	—

*The "Fire or Fire Hazard" category was added to the questionnaire after it had been administered to operators who participated in the Ft. Huachuca exercise.

7.1.3.17.3 Comments Made By Two Operators

a. Two operators commented: It was very difficult to hook up the generator/trailer to the truck. The wrong type of trailer is used for this generator. There is no crank on the trailer, so it took 7 guys to lift it onto the truck. The new, modified generator/trailer is dangerous because guys can't hold it up too long. Also, it is very hard to move the heavy trailer over rocks to get to the hook on the truck. The old 30 KW has a crank, so all you have to do is crank it up, push it a little bit, and then crank it back down onto the hook. This old type trailer should have been used with the new type generator.

b. One operator commented: The location of the fuel fill is inadequate. It's in a hole. It's hard to get the nozzle in there and it's hard to keep it in while refueling. When you get your hands in there to push the lever on the nozzle, your hands get scraped and bumped. This problem does not exist on the old 30 KW generators.

c. One operator commented: The design features for mounting the trailer safely are inadequate. There are not enough spaces for you to step on like with the old 30 KW generator/trailer. There are not enough walkspaces. There are not enough handholds to get ahold of when you are going to lift the trailer tongue.

7.1.3.17.4 Sound Level Measurements

These measurements were taken in the field during Golden Sabre XII. The system was under a load.

<u>Location of Measurement</u>	<u>dB(A) at one foot</u>
Operator's panel	83
Side to right of operator's panel	80
Side opposite to operator's panel	82
Side to left of operator's panel	84

7.1.3.17.5 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows:

a. The "power on" indicator light is yellow rather than green--as specified in MIL-STD-1472C. The lack of a "MAIN POWER ON-OFF" label for the main power switch may cause a lack of awareness as to whether or not electrical power is being applied to the power distribution system. In addition, the area around the main power terminals is not marked with a "CAUTION HIGH VOLTAGE, 120/208 VOLTS" warning and there is no protective cover over the lugs. A soldier could inadvertently come into contact with and suffer injury from terminals or cables under load. Finally, the emergency-stop control should be more clearly identified with bold letters indicating its function. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

b. The fan and belt inside the housing are only partially covered with a protective guard. A soldier could inadvertently stick his hand into the fan blades or get his clothing caught in the belts and pulleys. This situation is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

c. Exhaust gases are vented through a large vent in the baffling rather than through an exhaust pipe. This precludes the easy use of an extension tube for shunting the gases to the outside if the generator is used in an enclosed area. Without such an extension tube, there could be a build up of toxic exhaust fumes in the enclosed area. This problem is classified as Category I, Catastrophic with respect to hazard severity and as Level D, Remote with respect to hazard probability.

d. The step or landing at the operator's panel has sharp edges. A soldier could be injured if he fell or bumped against them, so the edges should be rounded. Also, the height of the trailer fender interferes with removing and replacing doors, causing operators to scrape their hands when engaging in this activity. These problems are classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

e. The recessed position of the fuel fill results in frequent spillage of fuel during the refueling process. Although the spilled fuel remains on the outside of the housing, it still poses a fire hazard. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

f. Ground rods and straps were not provided with the generator, but had to be obtained by the operators through other sources. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

g. The surfaces on the trailer fenders do not have non-slip characteristics. Thus, a soldier standing on them could easily slip and fall if the fenders were wet from rain or dew. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

h. The trailer was not adequate for the generator. There was no jack for raising the tongue so it could be hooked onto a truck. The weight of the generator/trailer plus the lack of adequate handholds made it very difficult to manhandle. In addition, the generator was somewhat top heavy on this trailer. These problems are classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

7.1.3.18 Manufacturer AQ, 30 kW, 60 Hz Generator

7.1.3.18.1 System Safety Checklist

- a. There is no green indicator light to indicate when power is on.
- b. The area around the main power terminals is not marked with a "CAUTION HIGH VOLTAGE, 120/208 VOLTS" warning.
- c. The generator provides a main power switch which cuts off all power to the equipment, but it is labeled "CKT BRK--Close, Open". It should be labeled "Main Power On-Off."
- d. Exposed belts do not have adequate safety covers. Fan and belt guards are needed.
- e. The access doors and latches have not been designed to prevent injury to personnel. The doors can be accidentally dislodged from the "opened" position and fall on the operator or other personnel in the vicinity. The doors should have positive locks for the "opened" position.
- f. There are sharp edges on the operator panel doors and on the acoustical extension at the rear of the unit. These edges may cause injury to personnel.
- g. Indicator lights are not properly color-coded. The light associated with the "CKT BRK Close-Open" switch is yellow. It should be green.

7.1.3.18.2 Ratings Made By One Operator

The tabulation of operators' responses to the safety questionnaire is shown below.

Table 7-16. Number of operators checking each category in the safety questionnaire (Manufacturer AQ, 30 kW, 60 Hz Generator)

	I Have Experienced	I Have Not Experienced But Is A Problem	Not A Problem	Was Not In A Position To Say
<u>Safety Incident</u>				
a. Electrical Shock	—	—	1	—
b. Fire or Fire Hazard*	—	—	1	—
c. Burns	—	—	1	—
d. Cuts, Scrapes, or Punctures	—	—	1	—
e. Extreme Temperature	—	—	1	—
f. Extreme Brightness	—	—	1	—
g. Extreme Loudness	—	—	—	—
h. Noxious Fumes	—	1	—	—

*The "Fire or Fire Hazard" category was added to the questionnaire after it had been administered to operators who participated in the Ft. Huachuca exercise.

7.1.3.18.3 Comments Made By One Operator

- a. The operator commented: When you stand near the exhaust system, you're exposed to a nasty smell. You don't get sick though.
- b. The operator commented: Overall, it is one of the best generators I have worked with. I couldn't believe how quiet it was, compared to the older 30 KWs.

7.1.3.18.4 Sound Level Measurements

These measurements were taken in a motor pool. No load was on the system.

<u>Location of Measurement</u>	<u>dB(A) at one foot</u>	<u>Distance From Generator to 85 dB(A) Contour</u>
Operator's panel (with panel doors open, standing on platform)	81	N/A
Operator's panel (in front of baffling, standing on ground)	86	2 ft. Ø in.
Side to right of operator's panel	84	N/A
Side opposite to operator's panel	93	4 ft. Ø in.
Side to left of operator's panel	82	N/A

7.1.3.18.5 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows:

a. The "power on" indicator light is yellow rather than green--as specified in MIL-STD-1472C. The main power switch is labeled "CKT BRK Close-Open"; it should be labeled "Main Power ON-Off". The present label may cause a lack of awareness as to whether or not electrical power is being applied to the power distribution system. In addition, the area around the main power terminals is not marked with a "CAUTION HIGH VOLTAGE, 120/208 VOLTS" warning. Thus, a soldier could inadvertently come into contact with and suffer injury from terminals or cables under load. Finally, the emergency-stop control should be more clearly identified with bold letters indicating its function. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

b. The fan and belt inside the housing are only partially covered with a protective guard. A soldier could inadvertently get his fingers or clothing caught in the belts or pulleys. This situation is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

c. The doors on the generator are held in the "opened" position by the overlap of a right-angle bracket on the door and a right-angle bracket on the top of the generator. The doors will not stay open in this position. Also, if a soldier who is working on the generator stands up and inadvertently bumps the door with his shoulder or back, the door could come loose and fall down on him, causing personal injury. This is a problem because the doors are hinged in the middle and are difficult to control once they are released from the latched position. A lock-mechanism that precludes unlatching by accidental contact would alleviate the problem. This hazard is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

d. The operator panel doors and the acoustical extension at the rear of the generator have sharp edges. A soldier could be injured if he fell or bumped against them, so these edges should be rounded. This problem is classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

e. Sound levels near the generator exceed 85 dB(A), the upper limit for steady state noise specified in MIL-STD-1474B(MI). Hearing protection and a "CAUTION, HIGH INTENSITY NOISE" stenciled warning are required [see SECTION 4.3, MIL-STD-1474B(MI)]. This problem is classified as Category III, Marginal with respect to hazard severity and as Level D, Remote with respect to hazard probability.

7.1.3.19 Manufacturer G, 30 kW, 60 Hz Generator

7.1.3.19.1 System Safety Checklist

- a. The area around the main power terminals is not marked with a "CAUTION HIGH VOLTAGE, 120/208 VOLTS" warning.
- b. The main power switch is not labeled; it should be labeled as "Main Power On-Off".
- c. There are no emergency controls on the generator.
- d. Ground rods and straps were not provided with the unit.

7.1.3.19.2 Ratings Made By Four Operators

The tabulation of operators' responses to the safety questionnaire is shown below.

Table 7-17. Number of operators checking each category in the safety questionnaire (Manufacturer G, 30 kW, 60 Hz Generator)

	I Have Experienced	I Have Not Experienced But Is A Problem	Not A Problem	Was Not In A Position To Say
<u>Safety Incident</u>				
a. Electrical Shock	—	2	4	—
b. Fire or Fire Hazard*	1	—	2	1
c. Burns	—	—	3	1
d. Cuts, Scrapes, or Punctures	—	—	3	1
e. Extreme Temperature	1	—	2	1
f. Extreme Brightness	—	—	3	1
g. Extreme Loudness	—	—	3	1
h. Noxious Fumes	—	—	3	1

*The "Fire or Fire Hazard" category was added to the questionnaire after it had been administered to operators who participated in the Ft. Huachuca exercise.

7.1.3.19.3 Comments Made By Four Operators

- a. Two operators commented: There is not enough room in the cramped power connections compartment. When all of our cables were connected, we couldn't put the plastic safety guard back over the lugs. We just left it off.

- b. One operator commented: The fuel leak we had was a fire hazard.
- c. One operator commented: One of our generators overheated (to 225°F) when acoustical foam fell off and blocked the air intake.
- d. Two operators commented: The water/coolant fill is on top of the generator. You have to climb up there and carry your coolant with you. It's kind of a safety hazard. There are no steps or anything. You just have to pull yourself up there.
- e. One operator commented: The fender wall gets in the way of pulling maintenance on the wheels. You have to get another jack and jack up the fender wall to get the tire off. This is a safety hazard because no jack will reach that high. You have to get same wood to build up a base on top of the jack.
- f. One operator commented: The trailer is very top heavy. I almost turned mine over twice on rough terrain. One set of duals came completely off the ground.

7.1.3.19.4 Sound Level Measurements

These measurements were taken in the field in conjunction with an infrared photographic test. No load was on the system.

<u>Location of Measurement</u>	<u>dB (A) at one foot</u>
Operator's panel	73
Side to right of operator's panel	75
Side opposite to operator's panel	78
Side to left of operator's panel	72

7.1.3.19.5 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows:

a. The lack of a "Main Power On-Off" label on the main power switch may cause a lack of awareness as to whether or not electrical power is being applied to the power distribution system. In addition, the area around the power connections is not marked with a "CAUTION HIGH VOLTAGE, 120/208 VOLTS" warning. A soldier could inadvertently come into contact with and suffer injury from terminals or cables under load. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

b. Ground rods and straps were not provided with the generator. The operators had to obtain them through other sources. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

c. There is insufficient room in the power connections compartment to replace the safety guard after the power cables are connected to the lugs. When the safety guard is left off, soldiers can easily come into contact with the terminals. This problem is classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

d. A fuel leak on one generator resulted in the accumulation of fuel around the generator. This created a fire hazard. The situation is classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

e. The acoustical foam blocked the air intake of one generator. This caused the generator to overheat. The problem is classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

f. The lack of steps or a ladder for climbing to the top of the generator housing to check the radiator could cause an operator to fall off the generator. This is classified as Category II, Critical with respect to hazard severity and as Level B, Reasonably Probable with respect to hazard probability.

g. The trailer is not designed so that the tires may be changed expeditiously. A soldier must use a jack with a makeshift platform in order to raise the trailer fender to change a tire. This requirement endangers personnel because of the unsteadiness of the jack. The problem is classified as Category II, Critical with respect to hazard severity and as Level D, Remote with respect to hazard probability.

h. The generator/trailer is too top heavy. A driver almost turned one over several times in rough terrain. The problem is classified as Category I, Catastrophic with respect to hazard severity and as Level D, Remote with respect to hazard probability.

7.1.3.20 Manufacturer H, 30 kW, 60 Hz Generator

7.1.3.20.1 System Safety Checklist

- a. There is no green indicator light to indicate when power is on.
- b. The main power switch is not clearly identified.
- c. There are no emergency controls on the generator.
- d. Access doors have not been designed to prevent injury to personnel. The operator's panel door has no fastener, latch, or brace to hold it open; therefore, the door can be blown shut.
- e. The corners of doors are sharp and may cause injury to personnel. Door corners should be rounded.
- f. The access doors weigh approximately 47 lbs. each, but are not marked to indicate lifting requirements.
- g. The generator has not been designed to preclude the accidental ignition of hazardous atmospheres. The fuel fill is located inside the acoustical enclosure.
- h. Ground rods and straps are not provided with the generator.
- i. A ground stud is not provided at the power entry box. The box is attached to a trailer which has a ground stud.

7.1.3.20.2 Ratings Made By Twelve Operators

The tabulation of operators' responses to the safety questionnaire is shown below.

Table 7-18. Number of operators checking each category in the safety questionnaire (Manufacturer H, 30 kW, 60 Hz Generator)

	I Have Experienced	I Have Not Experienced But Is A Problem	Not A Problem	Was Not In A Position To Say
<u>Safety Incident</u>				
a. Electrical Shock	—	1	9	2
b. Fire or Fire Hazard*	—	2	9	1
c. Burns	1	2	8	1
d. Cuts, Scrapes, or Punctures	1	2	8	1
e. Extreme Temperature	—	—	12	—
f. Extreme Brightness	—	—	12	—
g. Extreme Loudness	—	—	12	—
h. Noxious Fumes	1	—	11	—
i. Other (specify)	—	—	—	—
<u>Baffles Pinching</u>	1	—	—	—

*The "Fire or Fire Hazard" category was added to the questionnaire after it had been administered to operators who participated in the Ft. Huachuca exercise.

7.1.3.20.3 Comments Made By Twelve Operators

a. One operator commented: There is a possible safety problem with the fuel fill being inside. There is a chance of spilling fuel inside the generator. The generator should have an external fuel fill--not only for ease of refueling but also for safety.

b. Two operators commented: The doors to the engine compartment are very inadequate. When you refuel, you've got to take the doors off while you're standing on the wheel well. There's no place to put the doors on the generator and it's hard to put the heavy, bulky doors down on the ground, especially if you're by yourself. Suggestion: Put hinges and a different type of latch on the doors so you don't have to take them completely off. The present latches can be turned too far in one direction; then, they have to be turned completely back in order to refasten the doors.

c. One operator commented: The doors should have hinges because they are heavy, hard to tighten down, and hard to remove. If the spin-type door latches don't catch exactly right, the panels will fall off as you go down the road. To remove a door, you have to tilt it back, pull it off the lip, and set it aside. If you're in a confined area when you take a door off, you can easily get it hung up on bushes or camouflage net--causing you to fall off the generator or drop the door on your partner or yourself. Suggestion: Replace the spin-type door latches with flip-type latches like the ones on mil std generators. These latches are a lot more efficient and are faster to open. We definitely need quick-opening doors to get inside the generator to put out a fire or take care of some other emergency.

d. Two operators commented: The oil is hard to check when the engine is hot. It's easy to get burned. I got a contact burn when I touched the engine block.

e. One operator commented: The oil fill is hard to reach. You must take two doors off, then you must contend with a bar in the same position as the oil fill. You bang your hands in there.

f. Two operators commented: The screen covering the baffle on the top rear is mounted poorly. Along with being a cut and puncture hazard, it is also constantly getting caught in the camouflage. In my opinion, this is the most considerable flaw in this generator (along with its mounting to the trailer).

g. One operator commented: Once, when I was taking off a door, it fell off and scraped me.

h. One operator commented: There is a good chance of spilling fuel because of the internal location of the fuel fill. In case of a fire, the doors cannot be opened very fast.

i. One operator commented: The potential for getting burned exists when the operator checks the radiator and batteries. If you drop the fuel cap, forget about retrieving it until the engine cools.

j. One operator commented: The baffles and doors can pinch fingers.

k. One operator commented: The possibility of getting shocked is not that great if the operator makes sure he puts the cover on the power box down. However, I don't like the turn-screw connectors which lock the cover in place. If you don't get the turn screw in and turned, it will pop open. I prefer something that could be bolted, or more firmly held in place.

l. One operator commented: A fire hazard exists when fuel is standing in the bottom of the engine compartment. Also, fumes from standing fuel are a problem if the system has been shut up and you open the door to stick your head in to check something.

m. One operator commented: The fuel gauge could not be seen very well. You have to crawl inside the compartment to see it. If the engine is hot, you could get burned.

n. One operator commented: It takes too long to get to the circuit breaker inside the operator's panel for emergency shutdown. The time delay is due mainly to the type of latch on the operator's panel door.

o. One operator commented: The wires in the cables are color-coded but the lugs are numbered or lettered. Information in the manual should tell me what color to hook-up to which number.

p. One operator commented: The oil fill is very close to the fuel fill. During the daylight you can tell the difference between them, but at night (under blackout conditions) it would be possible to put oil in the diesel spout or vice versa. This would damage the equipment.

q. One operator commented: The operator's panel should be located at the rear of the generator to avoid having to climb over the tongue of the trailer, the power cables, etc. If you had mud on your boots, you could easily slip and get hurt.

r. One operator commented: You have to stick your head inside the housing area to check the batteries. It is hot in there, and if it's wet, you could slip and fall into the engine.

s. One operator commented: It is difficult to see the level of the coolant. If the engine is running or is hot, it is very difficult to check coolant level because the water/coolant fill is above the fan. This is a safety problem.

t. One operator commented: The brake lines on the trailer were cut twice while backing the generator in muddy field conditions. They were caught between the vehicle and the trailer during a jackknife. We found that we could not back the trailer in the mud, so we just used 10 people to push it in place.

u. One operator commented: You don't have the problem of the hot exhaust gases burning up the camouflage net like with some of the other generators.

v. One operator commented: The safety cover that was supposed to be covering the lugs could not be closed. This could have caused serious injury to personnel.

w. One operator commented: With all the fuel spilled in the generator compartment, it is hard to locate fuel leaks.

x. One operator commented: When it's cloudy like today, it's hell trying to find the oil dipstick hole. Lighting is needed on the inside of the generator.

7.1.3.20.3 Sound Level Measurements

These measurements were taken in the field in conjunction with an infrared photographic test. No load was on the system.

<u>Location of Measurement</u>	<u>dB(A) at one foot</u>
Operator's panel	79
Side to right of operator's panel	81
Side opposite to operator's panel	76
Side to left of operator's panel	82

7.1.3.20.5 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows:

- a. The lack of a green indicator light to indicate when power is on and the lack of a "Main Power On-Off" label on the main power switch may cause a lack of awareness as to whether or not electrical power is being applied to the power distribution system. A soldier could inadvertently come into contact with and suffer injury from terminals or cables under load. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.
- b. The door to the operator's panel does not have a positive lock mechanism to secure it in the "opened" position. Consequently, the door can be blown or pushed against an operator who is standing at the operator's panel. An injury could occur. This problem is compounded by the fact that the door has sharp corners. The hazards are classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.
- c. The access doors on the sides of the generator weigh 47 pounds each. They are difficult to handle and exceed the weight limitation specified in MIL-STD-1472C. This standard sets a weight limitation of 35 pounds for an item being lifted five feet off the ground by one male. The corresponding weight limitation for females is 23 pounds. Each door should be marked with a caution sign indicating the weight of the door and the requirement for a two-person lift. In addition, it is difficult and time consuming to remove the doors. In case of an emergency such as a fire, it would take too long to use the multiple-turn latches to remove the side panels to gain access to the engine and generator area, or to remove the door to the operator's panel to gain access to the main power switch. Also, it is difficult to determine whether a door is secured in position; consequently, the door could fall off and be damaged while the system was being moved or towed. These problems are collectively classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

d. The fuel fill is located inside the acoustical enclosure, so any fuel that is spilled accumulates on the floor of the enclosure around the base of the engine and generator. This creates a fire hazard and makes it difficult to detect fuel leaks. This spillage problem is compounded by the fact that fuel sometimes backs-up out of the fuel tank during the refueling process. The fuel fill should be located outside the enclosure so that spilled fuel will be absorbed into the earth or will evaporate. This problem is classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

e. Ground rods and straps were not provided with the generator. The operators had to obtain them through other sources. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

f. There is no platform for the operators to stand on when they check the control panel. They have to climb over cables and balance themselves on the frame of the trailer. This design limitation increases the chances of personnel falling and being injured, especially if it is wet and muddy. This problem is classified as Category III, Marginal with respect to hazard severity and as Level B, Reasonably Probable with respect to hazard probability.

g. The steel screen mesh that covers the exhaust vent on the top of the acoustical housing gets caught on tree limbs and other overhanging items. When this occurs, the mesh is bent upwards and its sharp edges are exposed. Operators may scrape their hands on these edges when they place camouflage nets over the generator. This problem is classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

h. The power connections compartment is too cramp. If a large number of cables have to be hooked up, operators remove the safety cover on the switch box. This creates a safety hazard since the terminals are exposed. A larger switch box is needed. This problem is classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

i. The acoustical housing extends beyond the end of the trailer and has no bumper or other mechanism to prevent it from being damaged if it hits some obstacle. This problem is classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

j. The potential for getting burned on the hot engine is great because the operator must get close to the engine to check various items such as oil level, coolant level, battery fluid level, and fuel level. The oil fill, in particular, is difficult to reach without coming into contact with the engine. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

k. The oil fill is close to the fuel fill. Under blackout conditions, an operator might inadvertently put oil in the fuel fill, or vice versa. Equipment damage would result. This problem is classified as Category II, Critical with respect to hazard severity and as Level D, Remote with respect to hazard probability.

1. The trailer brake lines are poorly located. If the trailer jackknives, the lines may be caught between the trailer and the tow vehicle. If the lines are cut, a safety incident might occur. Thus, there should be a better way of securing the brake lines to the trailer. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

7.1.3.21 Manufacturer I, 30 kW, 60 Hz Generator

7.1.3.21.1 System Safety Checklist

- a. There is no green indicator light to indicate when power is on.
- b. The terminal area is marked with a "DANGER HIGH VOLTAGE" stencil. TOP 6-2-507 recommends using a yellow stencil that reads "CAUTION HIGH VOLTAGE, XXX."
- c. The main power switch is not located on the operator's control panel. It is located behind a metal door beneath the operator's panel.
- d. The cover over the terminal lugs does not adequately prevent a soldier from inadvertently touching the lugs when they are carrying a load.
- e. There are no emergency controls on the generator.
- f. The radiator fan does not have an adequate safety cover around it. The fan is exposed on the top half. The present cover should be extended to cover the entire fan.
- g. There is only one jack to support the front of the trailer. Two are needed to provide better balance and stability for the generator/trailer.
- h. Parts and components are not free from the potential for releasing toxic fumes or vapors. Exhaust gases are vented upward through a large areal vent. Since the gases do not converge to a small diameter outlet, it would be hard to divert them with an extension pipe or tube.
- i. Sharp, overhanging edges and corners have not been eliminated; therefore, injury to personnel is possible. For example, the door to the operator's panel is too low when it is in the "up" position. A tall soldier can bump his head fairly easily when working around the panel door.
- j. The lifting rings on the generator are too small to fit the size of crane hooks used by Army engineer units.

7.1.3.21.2 Ratings Made By Nine Operators

The tabulation of operators' responses to the safety questionnaire is shown below.

Table 7-19. Number of operators checking each category in the safety questionnaire (Manufacturer I, 30 kW, 60 Hz Generator)

	I Have Experienced	I Have Not Experienced	Not A Problem	Was Not In A Position To Say
		But Is A Problem		
<u>Safety Incident</u>				
a. Electrical Shock	—	2	6	1
b. Fire or Fire Hazard*	—	—	6	—
c. Burns	—	—	8	1
d. Cuts, Scrapes, or Punctures	—	—	8	1
e. Extreme Temperature	—	—	8	1
f. Extreme Brightness	1	—	7	1
g. Extreme Loudness	—	—	8	1
h. Noxious Fumes	—	—	7	1

*The "Fire or Fire Hazard" category was added to the questionnaire after it had been administered to operators who participated in the Ft. Huachuca exercise.

7.1.3.21.3 Comments Made By Nine Operators

- Three operators commented: The plexiglass cover over the load terminals is inadequate. It does not protect anyone from getting shocked.
- One operator commented: The green light on the generator is too bright for use during blackout conditions. It causes an unsafe condition to exist during tactical maneuvers.
- One operator commented: To camouflage the generator, you have to stand on top of it. While there, you are exposed to noxious fumes coming from the exhaust on the top.
- Two operators commented: The fuel tank is in the wrong place. It is too low to the ground and could get punctured while being transported cross-country. This could create a safety problem.

e. One operator commented: It would help to have footholds or rungs for getting on top of the generator to check/service the radiator.

f. One operator commented: When you take the doors off, it's pretty hot in there. There's not enough ventilation in there--there's just that one place on top. The unit needs more than one ventilation opening. If you have to work on it, it's hot.

g. One operator commented: The fuel fill is too small. We had to use a funnel to fill from a tank in the motor pool. In the field, the nozzle on the tanker worked O.K.

7.1.3.21.4 Sound Level Measurements

These measurements were taken in the field while the system was under a load.

<u>Location of Measurement</u>	dB(A) at one foot (Ft. Huachuca)	dB(A) at one foot (Ft. Hood)
Operator's panel (with door open)	68	74
Operator's panel (with door closed)	67	74
Side to right of operator's panel	67	71
Side opposite to operator's panel	67	71
Side to left of operator's panel	67	71

7.1.3.21.5 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows:

a. The lack of a green indicator light to indicate when power is on, and the location of the main power switch behind a door beneath the operator's panel rather than on the operator's panel, may cause a lack of awareness as to whether or not electrical power is being applied to the power distribution system. A soldier could inadvertently come into contact with and suffer injury from terminals or cables under load. In addition, the flexible cover over the terminal lug area is not sufficient to keep soldiers from inadvertently sticking their hands in this area. This is especially true if there are several cables connected to the lugs. In such cases, the cover cannot be fastened down over the cables. Finally, the warning stencil above the terminal area does not conform to MIL-STD-454, ANSI Z35 1-1972, and TECOM TOP 6-2-507. The latter document indicates that voltages in the range of 70 to 500 should be marked with "CAUTION HIGH VOLTAGE" in yellow gothic capitals on a black background and with "XXX VOLTS" in black numbers/letters on a yellow background. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

b. The fan and belt inside the housing are only partially covered with a protective guard. A soldier could inadvertently stick his hand into the fan blades or get his clothing caught in the belts and pulleys. This situation is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

c. There is only one jack on the trailer to support the generator in the stand alone mode. A jack on each side of the tongue would give the trailer more stability. This situation is classified as Category II, Critical with respect to hazard severity and as Level D, Remote with respect to hazard probability.

d. Exhaust gases are vented upward through a large vent in the baffling rather than through an exhaust pipe. This precludes the easy use of an extension tube for shunting exhaust gases to the outside of an enclosed area, when the generator is used in such a configuration. Without the extension, there could be a build up of toxic fumes in the enclosed area. In addition, operators are exposed to hot exhaust gases when they climb on top of the generator to check/service the radiator and to put up camouflage nets. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

e. There are no steps or a ladder for climbing to the top of the generator housing to check the radiator. An operator could fall off the generator. This problem is classified as Category II, Critical with respect to hazard severity and as Level B, Reasonably Probable with respect to hazard probability.

f. The door to the operator's panel swings upward (rather than to the side). It can be locked in the "up" position such that it extends outward from the generator at a 90° angle. Soldiers who are above-average height can easily bump their heads on the opened door and suffer cuts or bruises. This problem is classified as Category III, Marginal with respect to hazard severity and as Level B, Reasonably Probable with respect to hazard probability.

g. The type of door latch used on access doors does not allow operators to tell if the doors are adequately secured when closed. Consequently, the doors may blow off when the generator is started. This poses a hazard to soldiers nearby. This problem is classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

h. The lifting rings on the generator are too small for the size of crane hooks typically used by Army engineer units. In addition, more stability would be achieved if the rings were located on the sides of the generator rather than on the corners. The current position of the rings increases the likelihood of a generator's falling out of the cables when being moved by a crane. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level D, Remote with respect to hazard probability.

i. The trailer is too low to the ground; thus, the fuel tank may be punctured while the generator is being towed cross-country. This design limitation creates a fire hazard. This problem is classified as Category II, Critical with respect to hazard severity and as Level D, Remote with respect to hazard probability.

j. The generator becomes very hot after it has operated several hours with the doors closed. When it gets hot, it becomes difficult to work on. To prevent operators from getting burned, "CAUTION HIGH TEMPERATURE" signs should be posted on the generator and warnings should be placed in the operator's manual. This problem is classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

7.1.3.22 Manufacturer A, 60 kW, 400 Hz Generator

7.1.3.22.1 System Safety Checklist

- a. There is no green indicator light to indicate when power is on.
- b. The area around the main power terminal is not marked with a "CAUTION HIGH VOLTAGE, 120/208 VOLTS" stencil.
- c. The main power switch is not clearly identified. It is labeled "CKT BRK CLOSE-OPEN"; it should be labeled "MAIN POWER ON-OFF".
- d. Emergency controls are placed in readily accessible locations but are not clearly identified.
- e. Fans and belts do not have adequate safety covers. The fan has a half-cover, but this is not sufficient for safe operation.
- f. The doors are very heavy. If someone accidentally bumps a door while it is latched in the "opened" position, the door could become unlatched and fall on personnel. An injury could result since the doors are heavy.
- g. Parts and components are not free from the potential for releasing toxic and explosive fumes or vapors. Presently, exhaust gases are really dispersed; they are not directed into a small hole or pipe so they can be easily vented to the outside of a shelter.
- h. The step located at the operator's panel has rough edges which may cause injury to personnel.
- i. Indicator lights are not properly color-coded, i.e., the "CKT BRK" light (which indicates that power is on) is amber rather than green.

7.1.3.22.2 Ratings Made By Four Operators

The tabulation of operators' responses to the safety questionnaire is shown below.

Table 7-20. Number of operators checking each category in the safety questionnaire (Manufacturer A, 60 kW, 400 Hz Generator)

	I Have Experienced	I Have Not Experienced But Is A Problem	Not A Problem	Was Not In A Position To Say
<u>Safety Incident</u>				
a. Electrical Shock	—	2	1	1
b. Fire or Fire Hazard*	—	1	2	1
c. Burns	1	—	2	1
d. Cuts, Scrapes, or Punctures	—	1	2	1
e. Extreme Temperature	2	1	—	1
f. Extreme Brightness	—	—	3	1
g. Extreme Loudness	—	—	3	1
h. Noxious Fumes	1	—	2	1

*The "Fire or Fire Hazard" category was added to the questionnaire after it had been administered to operators participating in the Ft. Huachuca exercise.

7.1.3.22.3 Comments Made By Four Operators

a. One operator commented: The brake lines were dented and cut whenever the tongue of the trailer was in the "up" position. Damaged brake lines could eventually lead to a safety incident.

b. Three operators commented: The fuel fill neck did not allow proper servicing of the generator without spillage. The angle of the filler neck was improper for refueling efficiency.

c. One operator commented: The trailer itself is too bulky for our needs. In one case, the tongue of the trailer snapped off. Personnel injury was a possibility.

d. One operator commented: One of the generators overheated. The "Overtemp" light came on, but the generator did not shut down.

e. Two operators commented: The lugs are too big and too close together. These aspects of the terminal area increase the chances of personnel injury and equipment damage. An operator could easily get the phases crossed or grounded.

f. One operator commented: The radiator needs a pressure relief cap for checking water/coolant level and servicing the radiator. Without one, the operator is likely to get scalded or burned.

7.1.3.22.4 Sound Level Measurements

These measurements were taken in the field during Golden Sabre XII. The system was under a load.

<u>Location of Measurement</u>	<u>dB(A) at one foot</u>	<u>Distance From Generator to 85 dB(A) Contour</u>
Operator's panel	95	8 ft. 11 in.
Side to right of operator's panel	97	10 ft. 1 in.
Side opposite to operator's panel	93	8 ft. 8 in.
Side to left of operator's panel	97	11 ft. 1 in.

7.1.3.22.5 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows:

a. The "power-on" indicator light is yellow rather than green--as specified in MIL-STD-1472C. The lack of a clear label on the main power switch may cause a lack of awareness as to whether or not electrical power is being applied to the power distribution system. In addition, the area around the main power terminals is not marked with "CAUTION HIGH VOLTAGE, 120/208 VOLTS" stencil. A soldier could inadvertently come into contact with and suffer injury from terminals or cables under load. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

b. The fan and belt inside the housing are only partially covered with a protective guard. A soldier could inadvertently stick his hand into the fan blades or get his clothing caught in the belts and pulleys. This situation is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

c. The doors on the generator are held in the "opened" position by the overlap of a right-angle bracket on the door and a right-angle bracket on the top of the generator. The doors will not stay open in this position. Also, if a soldier who was working on the generator stands up and inadvertently bumps the door with his shoulder or back, the door could come loose and fall down on him, causing personal injury. This is a problem because the doors are hinged in the middle and are difficult to control once they are released from the latched position. A lock mechanism that precludes unlatching by accidental contact would alleviate the problem. This hazard is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

d. Exhaust gases are vented through a large vent in the baffling rather than through an exhaust pipe. This precludes the easy use of an extension tube for shunting exhaust gases to the outside of an enclosed area, when the generator is used in such a configuration. Without the extension, there could be a build up of toxic fumes in the enclosed area. This problem is classified as Category I, Catastrophic with respect to hazard severity and as Level D, Remote with respect to hazard probability.

e. The step or landing at the operator's panel has sharp edges. A soldier could be injured if he fell or bumped against them, so the edges should be rounded. This problem is classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

f. The brake lines on the trailer are poorly located. The procedures used to place the trailer in a stand-alone position could cause damage to the brake lines. This problem is classified as Category I, Catastrophic with respect to hazard severity and as Level D, Remote with respect to hazard probability.

g. The recessed position of the fuel fill contributed to frequent spillage of fuel during the refueling process. Although the spilled fuel remains on the outside of the housing, it poses a fire hazard. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

h. The tongue of the trailer is not very sturdy. During a field exercise, one tongue snapped off, creating the potential for personal injury. This problem is classified as Category II, Critical with respect to hazard severity and as Level D, Remote with respect to hazard probability.

i. The generator does not automatically shut down when it overheats, even though the high temperature indicator light comes on. This problem is classified as Category I, Catastrophic with respect to hazard severity and as Level D, Remote with respect to hazard probability.

j. It is difficult to connect cables to the lugs because there is insufficient space between the lugs to easily insert and tighten down the cables. The cables must be twisted and bent to get them to fit. They can become frayed and damaged to the point that shorting is possible. This problem is classified as Category I, Catastrophic with respect to hazard severity and as Level D, Remote with respect to hazard probability.

k. The generator does not have a pressure release cap on the radiator to preclude the sudden release of steam from a loosened cap. This situation is classified as Category II, Critical with respect to hazard severity and as Level D, Remote with respect to hazard probability.

l. Sound levels near the generator exceed 85 dB(A), the upper limit for steady state noise specified in MIL-STD-1474B(MI). A caution sign was posted on the operator's panel, but it did not state that hearing protection is required. This problem is classified as Category III, Marginal with respect to hazard severity and as Level D, Remote with respect to hazard probability.

7.1.3.23 Manufacturer H, 60 kW, 60 Hz Generator

7.1.3.23.1 System Safety Checklist

- a. There is no green indicator light to indicate when power is on.
- b. The main power switch is not clearly identified.
- c. There are no emergency controls on the generator.
- d. Access doors have not been designed to prevent injury to personnel. The operator's panel door has no fastener, latch, or brace to hold it open; therefore, the door can be blown shut.
- e. The corners of doors are sharp and may cause injury to personnel. Door corners should be rounded.
- f. The access doors weigh about 47 lbs. each, but are not marked to indicate the weight and the requirement for two-person lift.
- g. The generator has not been designed to preclude the accidental ignition of hazardous atmospheres. The fuel fill is located inside the acoustical housing.
- h. Ground rods and straps are not provided with the generator.
- i. A ground stud is not provided at the power entry box. The box is attached to a trailer which has a ground stud.

7.1.3.23.2 Ratings Made By Two Operators

The tabulation of operators' responses to the safety questionnaire is shown below.

Table 7-21. Number of operators checking each category in the safety questionnaire (Manufacturer H, 60 kW, 60 Hz Generator)

<u>Safety Incident</u>	I Have Experienced	I Have Not Experienced	Not A Problem	Was Not In A Position To Say
		But Is A Problem		
a. Electrical Shock	—	1	1	—
b. Fire or Fire Hazard*	—	—	2	—
c. Burns	—	—	2	—
d. Cuts, Scrapes, or Punctures	2	—	—	—
e. Extreme Temperature	—	—	2	—
f. Extreme Brightness	—	—	2	—
g. Extreme Loudness	2	—	—	—
h. Noxious Fumes	—	—	2	—

*The "Fire or Fire Hazard" category was added to the questionnaire after it had been administered to operators who participated in the Ft. Huachuca exercise.

7.1.3.23.3 Comments Made By Two Operators

- a. One operator commented: Unless you put fuel in slowly, it will back up and spew out all over the generator.
- b. One operator commented: It is hard to get to the coolant fill. It is a safety problem if you try to fill the radiator while the generator is running. But, you normally wouldn't do this.
- c. One operator commented: The front of the trailer is a safety hazard. We had one person fall through where the A-frame is. You have to get on the frame to check the operator's panel, but when you open the door you have to step back or lean back. There is no place to stand. The small area immediately in front of the panel is too close to the panel, so you stand on the frame behind it.
- d. Two operators commented: When camouflaging, I scraped my hands on the screen on top of the generator.

e. One operator commented: Once at nighttime I fell off the platform in front of the operator's panel.

f. Two operators commented: The generator is too loud for tactical purposes. Under load, the noise level is still quite high, even with all the covers on.

g. One operator commented: There is no battle short switch. In a tactical situation, I may need something like that.

h. One operator commented: We had to hook up so many cables to the switch box that we had to make it unsafe by taking off the protective cover.

i. One operator commented: The back of the generator needs a bumper because it hangs over the back of the trailer and could be damaged if you backed into something.

j. One operator commented: One person got shocked when he hooked up equipment to load terminals. He was from TCATA and was hooking up data collection boxes to the terminals. But none of our people got shocked. If you are safety conscious, you can start, run, and shut the generator down without getting shocked.

7.1.3.23.4 Sound Level Measurements

These measurements were taken in the field in conjunction with an infrared photographic test. No load was on the system.

<u>Location of Measurement</u>	<u>dB(A) at one foot</u>
Operator's panel	81
Side to right of operator's panel	84
Side opposite to operator's panel	76
Side to left of operator's panel	84

7.1.3.23.5 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows.

a. The lack of a green indicator light to indicate when power is on and the lack of a "Main Power On-Off" label on the main power switch may cause a lack of awareness as to whether or not electrical power is being applied to the power distribution system. A soldier could inadvertently come into contact with and suffer injury from terminals or cables under load. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

b. The door to the operator's panel does not have a positive lock mechanism to secure it in the "opened" position. Consequently, the door can be blown or pushed against an operator who is standing at the operator's panel. An injury could occur. This problem is compounded by the fact that the door has sharp corners. These hazards are classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

c. The access doors on the sides of the generator weigh 47 pounds each. They are difficult to handle and exceed the weight limitation specified in MIL-STD-1472C. This standard sets a weight limitation of 35 pounds for an item being lifted five feet off the ground by one male. The corresponding weight limitation for females is 23 pounds. Each door should be marked with a caution sign indicating the weight of the door and the requirement for a two-person lift. In addition, it is difficult and time consuming to remove the doors. In case of an emergency such as a fire, it would take too long to use the multiple-turn latches to remove the side panels to gain access to the engine and generator area, or to remove the door to the operator's panel to gain access to the main power switch. Also, it is difficult to determine whether a door is secured in position; consequently, the door could fall off and be damaged while the system was being moved or towed. These problems are collectively classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

d. The fuel fill is located inside the acoustical enclosure, so any fuel that is spilled accumulates on the floor of the enclosure around the base of the engine and generator. This creates a fire hazard and makes it difficult to detect fuel leaks. The spillage problem is compounded by the fact that fuel sometimes backs-up out of the fuel tank during the refueling process. The fuel fill should be located outside the enclosure so that spilled fuel will be absorbed into the earth or will evaporate. This problem is classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

e. Ground rods and straps were not provided with the generator. The operators had to obtain them through other sources. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

f. There is no platform for the operators to stand on when they check the control panel. They have to climb over cables and balance themselves on the frame of the trailer. This design limitation increases the chances of personnel falling and being injured, especially if it is wet and muddy. This problem is classified as Category III, Marginal with respect to hazard severity and as Level B, Reasonably Probable with respect to hazard probability.

g. The steel screen mesh that covers the exhaust vent on the top of the acoustical housing gets caught on tree limbs and other overhanging items. When this occurs, the mesh is bent upwards and its sharp edges are exposed. Operators may scrape their hands on these edges when they place camouflage nets over the generator. This problem is classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

h. The power connections compartment is too cramp. If a large number of cables have to be hooked up, operators remove the safety cover on the switch box. This creates a safety hazard since the terminals are exposed. A larger switch box is needed. This problem is classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

i. The acoustical housing extends beyond the end of the trailer. The housing has no bumper or other mechanism to prevent it from being damaged if it hits some obstacle. This problem is classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

7.1.3.24 Manufacturer J, 60 kW, 60 Hz Generator

7.1.3.24.1 System Safety Checklist

- a. There is no green indicator light to indicate when power is on.
- b. The terminal area is marked with a white lettered/red background stencil which reads "DANGER HIGH VOLTAGE, 120/208." The words and colors are not consistent with those recommended in TOP 6-2-507.
- c. Emergency controls are not placed in a readily accessible location. They are placed too high on the operator's panel. Short operators won't be able to reach the controls without a step.
- d. The emergency controls are not clearly identified. The red knob on the control panel should be labeled "Emergency Stop" above the knob. The red knob on the hour meter box should also be labeled "Emergency Stop."
- e. Exposed belts do not have adequate safety covers. Covers are needed around the fan belts and alternator belts—on the operator panel side of the generator.
- f. The access doors were not designed to prevent injury to personnel. Opened doors can swing freely. Latches are needed on both sides of the generator to keep the doors stationary when they are opened for maintenance purposes.
- g. The skid has sharp edges which could cause injury to personnel. The sharp edges should be eliminated.
- h. The center of gravity for the generator/trailer is not co-located with the center of mass. The weight is heavily concentrated near the front of the trailer, making the generator/trailer likely to tip over from imbalance or from a strong wind. Being front heavy, the generator/trailer is difficult to handle, move, or position manually.
- i. The generator was not designed to prevent accidental ignition of fuel or fuel vapors. The fuel fill is presently located inside the acoustical housing; it should be placed outside the housing.
- j. The floor surfaces on the fender skirts of the trailer do not have non-slip characteristics.

7.1.3.24.2 Ratings Made By Three Operators

The tabulation of operators' responses to the safety questionnaire is shown below.

Table 7-22. Number of operators checking each category in the safety questionnaire (Manufacturer J, 60 kW, 60 Hz Generator)

	I Have Experienced	I Have Not Experienced But Is A Problem	Not A Problem	Was Not In A Position To Say
<u>Safety Incident</u>				
a. Electrical Shock	—	1	2	—
b. Fire or Fire Hazard*	—	1	2	—
c. Burns	—	—	3	—
d. Cuts, Scrapes, or Punctures	—	1	1	1
e. Extreme Temperature	—	—	3	—
f. Extreme Brightness	1	—	2	—
g. Extreme Loudness	1	—	2	—
h. Noxious Fumes	—	—	2	1

*The "Fire or Fire Hazard" category was added to the questionnaire after it had been administered to operators who participated in the Ft. Huachuca exercise.

7.1.3.24.3 Comments Made By Three Operators

- a. One operator commented: The power line hook-up area should have a better safety cover on it. When the power lines are connected, the cover is in the "up" position. This causes an open seam between the upper edge of the safety cover and the acoustical box. It is possible for rain to leak into the terminal area through this open seam.
- b. Two operators commented: There is no way to seal off the wires when the cables are hooked up to the lugs, such as the cable sock entry found on mil std 60 KW generators. A better-designed safety cover is needed.
- c. One operator commented: The power connection lugs are located below the operator's panel. This is a poor location because it is a highly trafficked area where operators would be subjected to high electrical shock hazards. I suggest that the power connection lugs be relocated.
- d. One operator commented: The inside location of the fuel fill creates a fire hazard. During the exercise, there was a lot of spillage inside the generator. The fuel fill should be relocated outside the acoustical box.

e. Two operators commented: Presently there is no way to keep a good wind from blowing an opened door against someone who is inside the unit checking gauges or working on the generator. Door latches are needed to keep opened doors in the "opened" position.

f. One operator commented: The generator was extremely loud when the generator was on and the doors were open.

g. One operator commented: The weight of the generator is not centered on the trailer—i.e., the generator/trailer is too front heavy. Six men were unable to pick up the tow area. Caterpillar should move the weight back on the trailer a bit.

h. One operator commented: If the generator were set up on a hillside, most of the weight would be placed on the one jack up front. This would create an unbalanced situation and a safety hazard. A second jack stand up front would help stabilize the situation.

i. Two operators commented: A slip-resistant surface on the fender skirt is needed. This would improve the design features for mounting the trailer safely.

j. One operator commented: The hook on the safety tow chain is too small to be hooked to a large truck.

k. One operator commented: The locking switch for the air brakes is too easy to unlock. The switch should have greater resistance against movement, so it is harder to inadvertently (or advertently) tamper with the air in the system. Presently, you may have no brakes and be unaware of it until they are needed.

l. One operator commented: The draw bar should be extended about a foot and the safety chains lengthened so that it would be easier to turn the generator/trailer. Also, the leveling jack should be much heavier or there should be one on each side of the trailer tongue.

7.1.3.24.4 Sound Level Measurements

These measurements were taken in the field during Golden Sabre XII. The system was under a load.

<u>Location of Measurement</u>	<u>dB(A) at one foot</u>	<u>Distance From Generator To 85 dB(A) Contour</u>
Operator's panel (with door open)	104	
Operator's panel (with doors closed)	88	1 ft. 11 in.
Side to right of operator's panel	80	Not Applicable
Side opposite to operator's panel	88	3 ft. 0 in.
Side to left of operator's panel	93	4 ft. 7 in.

7.1.3.24.5 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows:

- a. The lack of a green indicator light to indicate when power is on may cause a lack of awareness as to whether or not electrical power is being applied to the power distribution system. A soldier could inadvertently come into contact with and suffer injury from terminals or cables under a load. This problem is classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.
- b. The warning stencil near the power terminals does not conform to MIL-STD-454 and ANSI Z35.1-1972. For voltages in the range 70-500, the label should read, "CAUTION HIGH VOLTAGE, XXX." The letters should be yellow gothic capitals on a black background and the numbers/letters representing the voltage should be black on yellow. This problem is classified as Category III, Marginal and as Level D, Remote.
- c. The emergency controls are not clearly labeled as "Emergency Stop" and are somewhat difficult to be reached by short operators. These shortcomings could cause a delay in stopping the generator during an emergency. System damage or personnel injury could result. These problems are classified as Category II, Critical with respect to hazard severity and as Level D, Remote with respect to hazard probability.
- d. There are no safety guards around the fan and alternator belts on the operator panel side of the generator. The guards would prevent operators from getting their hands and clothing inadvertently caught in them. This problem is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.
- e. The doors to the generator housing do not have a positive lock system for keeping them in the "opened" position. The doors swing freely and can easily be caught by the wind and blown against a soldier working on the generator, causing personal injury. This problem is classified as Category III, Marginal with respect to hazard severity and as Level B, Reasonably Probable with respect to hazard probability.
- f. The edges and ends of the skid mounts are sharp. They could easily injure a soldier if he fell against them. This is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.
- g. The weight of the generator is concentrated toward the front of the trailer. It is difficult to manhandle the generator/trailer when positioning it. The degree of forward weight concentration also imbalances the generator/trailer and increases the likelihood that it will tip over when it is towed in a wind or on rough terrain. In addition, there is only one jack to support the trailer when it is in a stand-alone position. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level D, Remote with respect to hazard probability.

h. The fuel fill is located inside the acoustical housing so any fuel that is spilled accumulates on the floor around the base of the engine and generator. This creates a fire hazard. This condition is classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

i. The surfaces on the trailer fenders do not have non-slip characteristics. Thus, a soldier standing on them could easily slip and fall if the surfaces were wet from rain or dew. This problem is categorized as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

j. The safety cover over the terminal lugs does not provide a water tight seal and does not prevent a soldier from inadvertently slipping his hand into the terminal lug area and being shocked. A protective cover is needed to completely seal the area when the cables are connected to the lugs. In addition, the terminal lugs are located directly below the operator's panel. Consequently, the cables are in a position where they will be walked on frequently and possibly damaged. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level D, Remote with respect to hazard probability.

k. The safety tow chains are too small to adequately secure the trailer to a large tow truck. This problem is classified as Category II, Critical with respect to hazard severity and as Level D, Remote with respect to hazard probability.

l. The locking switch for the air brakes is too easy to unlock. The brakes may become unlocked inadvertently. This problem is classified as Category II, Critical with respect to hazard severity and as Level D, Remote with respect to hazard probability.

m. Sound levels near the generator exceed 85 dB(A), the upper limit for steady state noise specified in MIL-STD-1474B(MI). Hearing protection and a "CAUTION HIGH NOISE LEVEL" warning are required. This problem is classified as Category III, Marginal with respect to hazard severity and as Level D, Remote with respect to hazard probability.

7.1.3.25 Manufacturer I, 100 kW, 60 Hz Generator

7.1.3.25.1 System Safety Checklist

- a. There is no green indicator light to indicate when power is on.
- b. The terminal area is marked with a "DANGER HIGH VOLTAGE" stencil. TOP 6-2-507 recommends using a yellow stencil that reads "CAUTION HIGH VOLTAGE, XXX."
- c. The main power switch is not located on the operator's control panel. It is located behind a metal door beneath the operator's panel.
- d. The cover over the terminal lugs does not adequately prevent a soldier from inadvertently touching the lugs when they are carrying a load.
- e. There are no emergency controls on the generator.
- f. The radiator fan does not have an adequate safety cover around it. The fan is exposed on the top half. The present cover should be extended to cover the entire fan.
- g. There is only one jack to support the front of the trailer. Two are needed to provide better balance and stability for the generator/trailer.
- h. Parts and components are not free from the potential for releasing toxic fumes or vapors. Exhaust gases are vented upward through a large areal vent. Since the gases do not converge to a small diameter outlet, it would be hard to divert them with an extension pipe or tube.
- i. Sharp, overhangng edges and corners have not been eliminated; therefore, injury to personnel is possible. For example, the door to the operator's panel is too low when it is in the "up" position. A tall soldier can bump his head fairly easily when working around the panel door.
- j. The lifting rings on the generator are too small to fit the size of crane hooks used by Army engineer units.

7.1.3.25.2 Ratings Made By Three Operators

The tabulation of operators' responses to the safety questionnaire is shown below.

Table 7-23. Number of operators checking each category in the safety questionnaire (Manufacturer I, 100 kW, 60 Hz Generator)

	I Have Experienced	I Have Not Experienced But Is A Problem	Not A Problem	Was Not In A Position To Say
<u>Safety Incident</u>				
a. Electrical Shock	—	—	3	—
b. Fire or Fire Hazard*	—	—	3	—
c. Burns	—	—	3	—
d. Cuts, Scrapes, or Punctures	1	—	2	—
e. Extreme Temperature	—	1	2	—
f. Extreme Brightness	—	—	3	—
g. Extreme Loudness	—	—	3	—
h. Noxious Fumes	—	—	3	—
i. Other (specify)				
Very Hot Air Blowing On Top of Generator	1	—	—	—

*The "Fire or Fire Hazard" category was added to the questionnaire after it had been administered to operators who participated in the Ft. Huachuca exercise.

7.1.3.25.3 Comments Made By Three Operators

- a. One operator commented: The cover for the instrument panel is too low when it is in the "up" position. This creates a safety hazard for anyone six feet tall and above when he tries to walk underneath.
- b. One operator commented: The door latches are inadequate because they don't always catch to secure the door. The operator may not know this condition exists until he starts up the generator and the doors blow off. This is a safety hazard for anyone standing nearby.
- c. Two operators commented: It is dangerous to climb on top of the generator to check and service the radiator. There are no handholds or footholds to help the operator mount the acoustical housing. He could slip and fall very easily.

d. One operator commented: The generator needs a better cooling system. The exhaust air blowing straight out the top of the generator is very hot. This creates a safety hazard for the operator when he checks and services the radiator from the top of the unit.

e. One operator commented: When the generators were refueled by the fuel trucks, a lot of fuel was spilled and splashed around. Fuel was all over the ground. It was a safety hazard since someone could have dropped a cigarette on the ground. A larger neck on the fuel fill and a fuel funnel might keep the fuel from splashing around the sides of the generator and onto the ground.

7.1.3.25.4 Sound Level Measurements

These measurements were taken in the field in conjunction with an infrared photographic test. No load was on the system.

<u>Location of Measurement</u>	<u>dB(A) at one foot</u>
Operator's panel (with door open)	81
Operator's panel (with door closed)	78
Side to right of operator's panel	76
Side opposite to operator's panel	76
Side to left of operator's panel	77

7.1.3.25.5 Analysis

Analysis of the preceding safety results led to the identification and classification of safety problems as follows:

a. The lack of a green indicator light to indicate when power is on, and the location of the main power switch behind a door beneath the operator's panel rather than on the operator's panel, may cause a lack of awareness as to whether or not electrical power is being applied to the power distribution system. A soldier could inadvertently come into contact with and suffer injury from terminals or cables under load. In addition, the flexible cover over the terminal lug area is not sufficient to keep soldiers from inadvertently sticking their hands in this area. This is especially true if there are several cables connected to the lugs. In such cases, the cover cannot be fastened down over the cables. Finally, the warning stencil above the terminal area does not conform to MIL-STD-454, ANSI Z35.1-1972, and TECOM TOP 6-2-507. The latter document indicates that voltages in the range of 70 to 500 should be marked with "CAUTION HIGH VOLTAGE" in yellow gothic capitals on a black background and with "XXX VOLTS" in black numbers/letters on a yellow background. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

b. The fan and belt inside the housing are only partially covered with a protective guard. A soldier could inadvertently stick his hand into the fan blades or get his clothing caught in the belts and pulleys. This situation is classified as Category II, Critical with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

c. There is only one jack on the trailer to support the generator in the stand-alone mode. A jack on each side of the tongue would give the trailer more stability. This situation is classified as Category II, Critical with respect to hazard severity and as Level D, Remote with respect to hazard probability.

d. Exhaust gases are vented upward through a large vent in the baffling rather than through an exhaust pipe. This precludes the easy use of an extension tube for shunting exhaust gases to the outside of an enclosed area, when the generator is used in such a configuration. Without the extension, there could be a build up of toxic fumes in the enclosed area. In addition, operators are exposed to hot exhaust gases when they climb on top of the generator to check/service the radiator and to put up camouflage nets. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

e. There are no steps or a ladder for climbing to the top of the generator housing to check the radiator. An operator could fall off the generator. This problem is classified as Category II, Critical with respect to hazard severity and as Level B, Reasonably Probable with respect to hazard probability.

f. The door to the operator's panel swings upward (rather than to the side). It can be locked in the "up" position such that it extends outward from the generator at a 90° angle. Soldiers who are above-average height can easily bump their heads on the opened door and suffer cuts or bruises. This problem is classified as Category III, Marginal with respect to hazard severity and as Level B, Reasonably Probable with respect to hazard probability.

g. The type of door latch used on access doors does not allow operators to tell if the doors are adequately secured when closed. Consequently, the doors may blow off when the generator is started. This poses a hazard to soldiers nearby. This problem is classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

h. The lifting rings on the generator are too small for the size of crane hooks typically used by Army engineer units. In addition, more stability would be achieved if the rings were located on the sides of the generator rather than on the corners. The current position of the rings increases the likelihood of a generator's falling out of the cables when being moved by a crane. These problems are classified as Category I, Catastrophic with respect to hazard severity and as Level D, Remote with respect to hazard probability.

i. The trailer is too low to the ground; thus, the fuel tank may be punctured while the generator is being towed cross-country. This design limitation creates a fire hazard. This problem is classified as Category II, Critical with respect to hazard severity and as Level D, Remote with respect to hazard probability.

j. The generator becomes very hot after it has operated several hours with the doors closed. When it gets hot, it becomes difficult to work on. To help prevent operators from getting burned, "CAUTION HIGH TEMPERATURE" signs should be posted on the generator and warnings should be placed in the operator's manual. This problem is classified as Category III, Marginal with respect to hazard severity and as Level C, Occasional with respect to hazard probability.

7.4.6.2 MEP-005A, 30 KW, 60 Hz Generator with Large Muffler

This generator is identical to the one discussed in section 7.4.6.1, except that it has a large muffler rather than baffles for reducing noise. Consequently, the information from the System Safety Checklist and from the operators discussed under 7.4.6.1, with the exception of information pertinent to baffles, applies here.

7.4.6.2.1 System Safety Checklist

See section 7.4.6.1.1

7.4.6.2.2 Operator Ratings

See section 7.4.6.1.2

7.4.6.2.3 Operators Comments

See section 7.4.6.1.3

7.4.6.2.4 Sound Level Measurements

<u>Location of Measurement</u>	<u>dB(A) at one foot</u>	<u>Distance From Generator to 85 dB(A) Contour</u>
Operator's panel	99	10 ft. 8 in.
Side to right of operator's panel	92	6 ft. 2 in.
Side opposite to operator's panel	98	6 ft. 9 in.
Side to left of operator's panel	91	6 ft. 0 in.

7.4.6.2.5 Analysis

See section 7.4.6.1.5

7.4.6.5 MEP-114A, 30 KW, 400 Hz Generator

Since this generator was only briefly used on the field exercise of the test, there were no operators with experience on it who could provide reliable and valid safety information about it. However, from an operators point of view, the generator is identical to the MEP-115A, 60 KW, 400 Hz Generator. Consequently, the information in section 7.4.7.1 can also be applied to this generator.

RECOMMENDATIONS FOR PURCHASE DESCRIPTIONS

Human Factors. Each of the generators evaluated in this report has a number of human factors problems associated with it. A review of these problems led to the following list of design features which should be present on all mobile generator systems used by the Army. This list should be helpful to individuals who write purchase descriptions for the acquisition of future generators.

1. A fuel gauge, water/coolant gauge, and oil gauge (or oil dipstick) should be located externally to the acoustical housing surrounding the generator. More specifically, all gauges should be located on the operator's control panel. The fill points for fuel, water/coolant, and oil should also be located externally to the acoustical housing. The fuel fill should be located at trailer level at a safe distance from the batteries; the water/coolant fill should be located on top of the acoustical housing; and the oil fill should be located on the top or sides of the acoustical housing. Each system should be designed so that the generator can be serviced while it is running. Placing the fill points external to the sound-reducing equipment would allow servicing of the generator without jeopardizing the concealment tactics of a military unit, and would make servicing the generator easier.
2. The power connections compartment should be designed for accessibility, potential operational requirements, and safety. The lug terminals should be large enough and spaced far enough apart so that four or five large cables can be readily connected to the generator. The compartment should have a safety cover that can be secured in the "opened" position while cables are being connected and can be lowered to provide a safe, waterproof environment after the cables are connected. The entire power connections compartment should be located away from highly-trafficked areas, such as the immediate space around the operator's control panel. An operator cannot work efficiently or safely around a generator if he has to constantly climb over power cables.
3. In order to avoid equipment damage and personnel injury, the label for a designated terminal on an Army-procured commercial generator should be consistent with the label for the corresponding terminal on a military standard generator.
4. Access doors in the acoustical housing should be self-supporting so they can be opened quickly and easily. They should be hinged on one side and latched on the other (with tongue-and-slot catches). Multiple-turn latches should not be used since they interfere with normal and emergency operations of a generator. The doors should have positive locks or braces to secure them when they are in the "opened" position. (The "opened" position for an access door should be reached by a horizontal movement of the door, rather than a vertical movement.)
5. All indicator lights, gauges, and controls for the generator should be located on (or near) the operator's control panel. The entire control panel should be located externally to the acoustical housing and located in a readily accessible area around the generator. In addition, the control panel should be placed at eye-level for an average-height soldier standing on the ground. Placing the control panel at a proper height would make the generator easier to use during normal and emergency conditions.

6. Natural and artificial illumination around the operator's control panel should provide sufficient light for a variety of tactical situations. External, white lights should be used for panel lights and low luminance, integral red lights should be used for all gauges. The brightness of all lights should be adjustable and all lights should be extinguishable with on-off switches. This light configuration would allow maximum flexibility for operating during daytime, nighttime, and blackout conditions.

7. The batteries should be mounted side by side and located in a separate compartment having its own access door. When the door is opened, the batteries should slide in and out easily. The operator should be able to access each battery individually, without difficulty.

8. A generator/trailer should be sufficiently rugged to be towed successfully across rough terrain and still complete its mission. The size and weight of the generator should be compatible with the size and weight of the trailer. The center of gravity of the generator/trailer should be properly located so the generator/trailer is easy to tow, easy to set in place manually, and stable when at rest. The brakes should be reliable; in particular, they should not lock up during forward or backward movement. The tire configuration, tire size, and fender skirt design should facilitate transporting the generator and changing the tires. The chassis of the trailer should be high enough off the ground so the trailer does not drag when traveling over rough or hilly terrain.

9. The hook-up mechanism on the trailer should be designed so that one or two soldiers can easily and quickly hook the generator/trailer onto a tow vehicle, or remove the generator/trailer from the tow vehicle when it reaches its destination. The landing gear should be sturdy and easily cranked up and down. The trailer hook should protrude out enough so that the tow vehicle can make turns without damaging the tow bar of the trailer. The safety chains should be long enough and strong enough to ensure safe travel. The trailer should have a hand brake (rather than air brakes) to use when the generator/trailer is stationary.

10. The amount of workspace around the generator should be sufficient for the operator to perform his duties in a safe and timely manner. The design of the workspace should also facilitate the accomplishment of maintenance tasks. More specifically, walkways on the fender skirts should be at least 27 inches wide and be coated with skid-resistant material. Steps should be added to the sides of the trailer to assist operators when they mount the walkways. Handholds and footholds should be mounted on the sides of the acoustical housing of any generator which requires operators to climb on top of the housing to perform checks and services.

11. The amount of storage space on the generator/trailer should be sufficient for storing special tools, spare parts, fuel cans, fuel filters, oil cans, oil filters, grounding rods, and an operator's manual. The storage space should be lockable, so that pilferage can be controlled.

Safety. Each of the generators evaluated in this report has a number of safety problems associated with it. A review of these problems led to the following list of safety features which should be present on all mobile generator systems used by the Army. This list should be helpful to individuals who write purchase descriptions for the acquisition of future generators.

1. Generators should have a green indicator light on the operator's panel to indicate when power is on. In addition, the main power switch should be located on the operator's panel and should be labeled "Main Power On-Off." The absence of these features may cause a lack of awareness as to whether or not electrical power is being applied to the power distribution system. If power is being applied with no external indications of that fact, a soldier may inadvertently come in contact with (and suffer injury from) cables or terminals under load.

2. Terminal lug areas should have protective covers which prevent soldiers from inadvertently contacting terminals under load. In addition, the area should be labeled to conform with MIL-STD (military standard) 454, ANSI (American National Standards Institute) Z35.1-1972, and TECOM TOP (Test Operating Procedure) 6-2-507. Voltages in the range of 70 to 500 should be labeled with "CAUTION HIGH VOLTAGE" in yellow gothic capitals on a black background and with "XXX VOLTS" in black numbers/letters on a yellow background.

3. Ground rods and straps should be provided as part of each generator system.

4. A clearly identified, emergency shut-off control should be provided on generator systems which are normally shut down in several stages. The control should allow an operator or bystander to immediately and easily shut down the generator in case of an emergency.

5. Fan blades, belts, and pulleys should have protective guards around them to prevent a soldier from inadvertently getting a limb or clothing caught in moving parts.

6. The fuel fill should be located externally to the acoustical housing. Refueling typically involves some spillage of fuel, even when care is taken to avoid such an occurrence. When the fuel fill is located inside the acoustical housing, spilled fuel tends to accumulate and pose a fire hazard.

7. Exhaust gases should be directed upwards or downwards so that they are not vented directly at soldiers who are working on the generator or walking by it. In addition, the exhaust vent should be designed so that a tubular extension can be added to it. The extension could remove exhaust gases and fumes a safe distance from the generator if it were operating in an enclosed area.

8. Doors for the acoustical housing should be designed to allow rapid access to the generator and engine in case of emergencies such as fires. The access doors should be self-supporting, hinged on one side, and latched on the other (with tongue-and-slot catches). In addition, the hinged doors should have a positive locking mechanism which secures them when they are opened and prevents their being caught by the wind and slammed against an operator or bystander.

9. Corners and edges on the trailer, the access doors, and other parts of the generator/trailer should be rounded to reduce the number and severity of injuries to soldiers who accidentally fall against them.

10. The 1.5 KW generators should be labeled to indicate their weight. They are relatively heavy (over 100 pounds) but are small enough that they will be manually carried by soldiers from vehicles to emplacement locations.

11. To conform with MIL-STD-1474B(MI), generators should be marked with a "CAUTION, HEARING PROTECTION REQUIRED" stencil if their steady state noise level reaches 85 dB(A). The "CAUTION" should be in yellow gothic capitals on a black background, and the "HEARING PROTECTION REQUIRED" should be in black letters on a yellow background.

12. Walking spaces on trailer floors and fenders should have non-slip surfaces to prevent soldiers from slipping when the walkways are wet from rain, spilled oil, or spilled fuel.

13. Trailers should have safety chains which can be attached to the tow vehicle to prevent a trailer from breaking loose from the vehicle if the tow bar breaks.

14. Permanently fixed ladders or footholds/handholds should be mounted on the sides of the acoustical housing of those generators which require operators to climb on top of the housing to perform checks and services.

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